Environment Canada
Atmospheric Environment Service

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Service de l'environnement atmosphérique

The Climate of METROPOLITAN TORONTO

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THE CLIMATE OF CANADIAN CITIES

Number 1.	The climate of Ottawa-Hull, Ontario-Québec	1983
Number 2.	The climate of Edmonton, Alberta	1985
Number 3.	The climate of Calgary, Alberta	1987
Number 4.	The climate of Montréal, Québec	1987
Number 5.	The climate of Metropolitan Toronto, Ontario	1989

This series was initiated in response to a need to distribute to the public general and applied climatic information for Canadian urban areas. While the format and style of each publication varies depending on the writer, available climatic data, significance of local climatic factors and other circumstances, an attempt is made to standardize the format and content as much as possible to aid in the comparison of climatic conditions between various urban areas.

The Climate of METROPOLITAN TORONTO

Climatological Studies Number 41
The Climate of Canadian Cities Number 5

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B. Smith
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THE CLIMATE OF METROPOLITAN TORONTO

SUMMARY

The **climate** of Metropolitan Toronto can be enjoyable, stimulating, invigorating, and sometimes, downright unpleasant. This Environment Canada publication describes these and other aspects of Toronto's climate. The introduction outlines the four distinct seasons experienced in the area. Section I briefly describes the geographical and topographical influences determining the climate. Section II provides detail on several climatic elements, including temperature, precipitation, wind, cloud and sunshine, as well as uncomfortable and severe weather.

Because climate affects many aspects of Canadian society, a section (III) has been included on its impact on human activities in Toronto. The discussion concentrates on gardening, heating and cooling, and recreation. In Section IV, the climate of the future is considered along with its potential impact on Torontonians. Section V compares the climate of Toronto with that of other cities in Canada and around the world. A Glossary, following Section V, is provided to define certain technical terminology. Terms referenced in the Glossary are boldfaced as they first appear in the text. Appendices are included to give further information on climatic mean values and noteworthy meteorological events of the past.

SOMMAIRE

Le climat du Grand Toronto peut être agréable, stimulant, revigorant et, parfois, tout à fait déplaisant. La présente publication d'Environnement Canada décrit ces caractéristiques de même que d'autres aspects du climat de Toronto. Dans l'introduction, on examine les quatre saisons distinctes qu'on retrouve dans la région. La partie I décrit brièvement les influences géographiques et topographiques qui façonnent le climat. La partie II donne des détails sur plusieurs éléments climatiques, y compris la température, les précipitations, le vent, les nuages et l'ensoleillement, de même que les phénomènes météorologiques désagréables et violents.

Comme le climat influe sur de nombreux aspects de la société canadienne, on a inclus une partie (III) qui examine son influence sur les activités humaines à Toronto. La discussion porte sur le jardinage, le chauffage et la climatisation, de même que sur les activités récréatives. Dans la partie IV, on examine le climat de l'avenir, de même que son influence éventuelle sur les Torontois. Dans la partie V, on compare le climat de Toronto à celui d'autres villes du Canada et du monde entier. A la fin de la partie V, vous trouverez un glossaire qui définit certains termes techniques; ces termes sont en caractères gras dans le texte la première fois qu'ils apparaissent. On a inclus des annexes pour donner des renseignements supplémentaires sur les valeurs climatiques moyennes ou sur les événements météorologiques du passé qui sont dignes d'attention.

FOREWORD

The Climate of Metropolitan Toronto is one of a series of climatic studies planned for different cities in Canada. Similar publications are available to describe the climates of Ottawa-Hull, Edmonton, Calgary and Montreal.

This particular publication is intended for anyone interested in learning about the climate of Metropolitan Toronto. The users of such climatic information tend to be both plentiful and of varied backgrounds, ranging from the backyard gardener to the design engineer. For planners, this information is essential in designing protection from natural hazards and for planning efficient use of resources. Such planners consider climate in designing flood protection, for instance, or in locating factories or recreational activities, or in deciding appropriate agricultural crops. For other users, climatic information is useful in determining where to live or vacation, when to garden, which recreational equipment to purchase, or for general interest.

Whatever the reader's background, it is hoped that this publication will meet both the general requirements for planning and the popular demand for information. Accordingly, the publication avoids the use of very technical terms and attempts to provide explanations on the many atmospheric phenomena that shape Toronto's climate.

TABLE OF CONTENTS

	Page
Summary	iii
Foreword	v
Acknowledgements	xi
INTRODUCTION	1
The city and its climate	1
The four seasons	2
SECTION I - CLIMATE INFLUENCES	5
CLIMATE OBSERVING STATIONS	5
Figure 1 - Topographic map of the Toronto area with locations of some climatological stations	7
FACTORS THAT INFLUENCE CLIMATE	6
Geographical influences	6
Local influences	8
Table 1 - Influence of some local geographical features on climate	9
SECTION II - CLIMATIC ELEMENTS	11
TEMPERATURE	11
Figure 2 - Mean daily and extreme temperatures at Toronto (city)	11
Table 2 - Mean daily maximum and minimum temperatures for various sites in the Toronto area	13
Winter cold spells	14
Table 3 - Average number of occurrences of winter cold periods at Pearson International Airport with minimum temperatures of -15°C or colder	13
Winter mild spells	14
Table 4 - Average number of occurrences of winter mild periods at Pearson International Airport with minimum temperatures at and above 0°C	16

TABLE OF CONTENTS (continued)

Page

Summer heat waves 16

Table 5 - Average number of occurrences of summer hot periods at Pearson International Airport with maximum temperatures at or above 32°C 17

Summer cool spells 17

Uncomfortable weather 18

PRECIPITATION 18

Table 6 - Comparison of mean monthly precipitation amounts for various sites in the Toronto area 19

Figure 3 - Percentage frequency and amount of precipitation at Pearson International Airport 20

Table 7 - Mean number of days with measurable precipitation for various sites in the Toronto area 21

Table 8 - Mean number of days with measureable precipitation of various types at Pearson International Airport 22

Prolonged and heavy precipitation 22

Table 9 - Return-period rainfall amounts at Toronto (city) . 23

Dry spells 24

WIND 24

Table 10 - Prevailing wind directions at Pearson International Airport and Toronto Island Airport 26

Table 11 - Mean wind speed at Pearson International Airport and Toronto Island Airport 27

Wind chill 27

Table 12 - Average number of days per month that the wind chill lies within specific ranges at Pearson International Airport 28

HUMIDITY 28

Table 13 - Mean relative humidity and mean dew point temperature by month at 1 p.m. EST 29

TABLE OF CONTENTS (continued)

Page

Humidex 29

Table 14 - Average number of days per month that the humidex lies within specific ranges lasting at least one hour at Pearson International Airport 29

Fog 30

Table 15 - Average number of occurrences per month of fog of various durations restricting visibilities to 4 km or less 30

SUNSHINE AND CLOUD COVER 31

Figure 4 - Cloud cover at Pearson International Airport 31

Figure 5 - Total daylight hours and mean hours of bright sunshine at Toronto (city) 32

SEVERE WEATHER 32

Tornadoes and severe thunderstorms 32

Hurricanes 33

Winter severe weather 34

SECTION III - THE CLIMATE AND HUMAN ACTIVITIES 37

GARDENING 38

Table 16 - Average and extreme frost-free period for various sites in the Toronto area 37

Figure 6 - Ornamental plant hardiness zones in southern Ontario 39

HEATING AND AIR CONDITIONING 39

Table 17 - Average heating degree-days and cooling degree-days for various cities in Canada 40

Table 18 - Average heating degree-days for various sites in the Toronto area 40

RECREATION 44

TABLE OF CONTENTS (continued)

Page

SECTION IV - CLIMATE VARIABILITY AND CHANGE 45

SECTION V - TORONTO AND THE WORLD 47

Table 19 - Toronto and the World 48

Figure 7 - Areas of the World having a similar climate to that of Toronto 47

REFERENCES 51

GLOSSARY 53

APPENDICES

1. Climatic normals for Toronto (city) 55

2. Climatic normals for Toronto Pearson International Airport .. 59

3. Climatic normals in the Toronto area 65

4. Noteworthy meteorological events of the past 67

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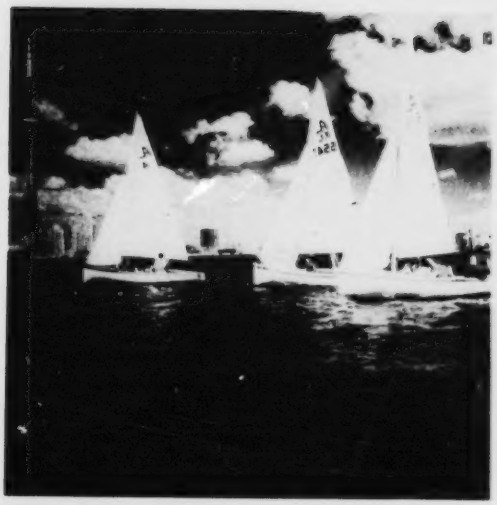
PICTURE CREDITS

Many of the photographs were supplied by the courtesy of the Metropolitan Toronto Convention and Visitors Association. Other sources are identified beneath the appropriate pictures; the following abbreviations are used:

A.E.S.	Atmospheric Environment Service Archives
Can. Wide	Canada Wide Feature Services Limited
Globe	Toronto Globe and Mail
M.T.R.L.	Metropolitan Toronto Reference Library
N.A.C.	National Archives of Canada
N.F.B.	National Film Board of Canada
Ont. Hydro	Ontario Hydro
Tor. Tel.	Toronto Telegram files, York University Archives



INTRODUCTION

THE CITY AND ITS CLIMATE

The word "toronto" comes from the Huron Indian language and is thought to mean "place of meeting" - a meaning that suits Metropolitan Toronto well. In the past, the area earned its title as part of an important Indian trail linking Lake Ontario and Lake Huron. Today, greater Metropolitan (Metro) Toronto earns this title as a meeting place for many people.

The modern Metro Toronto has become a vibrant and engaging city made up of numerous small neighbourhoods, giant skyscrapers, and a population in excess of 2 million people whose roots are spread all over the world. The area has grown to become Canada's largest urban centre with a heavy concentration of people, industry, business and culture in its vicinity.

Toronto's growth has been helped by its unique combination of geography and climate. Because of a location on the northwest shore of Lake Ontario, Toronto is well endowed with readily available natural resources. By having direct access to the Great Lakes water system, the area is provided with water for recreation, power generation, transportation, as well as for domestic and industrial purposes. The climate has also been beneficial. Toronto has one of the most reliable precipitation regimes in the world, with markedly dry or wet spells both uncommon. The normally reliable moisture and a relatively long growing season combine to allow agricultural productivity in the surrounding countryside to be among the highest in Canada.

The climate of Metro Toronto has some fairly unique features, including four well-marked seasons. Winters are normally cool to cold and summers are warm to sometimes hot; monthly precipitation amounts average around 65 mm of rain or rain and snow equivalent. A feature of the climate familiar to most Torontonians is the variety of **weather** on a day-to-day and year-to-year basis. Weather records from any site in the area indicate that the climate is anything but boring.

While the climate may be described as beneficial, the day-to-day weather and its vagaries occasionally present hardships. Sometimes, the usually reliable rainfall comes in the form of gentle rain while, at other times, it can fall as torrential downpours. In winter, the odd snowstorm creates blinding white-

outs, disrupted air transport, and traffic chaos. Periods of bitter cold, however brief, can also be expected. In order to cope with these times of vigour, Metro Toronto has undertaken major underground development and has built about 9 km of underground shopping arcades where one can buy anything from the services of a dentist to the profusions of a supermarket. Summers, on the other hand, can occasionally bring times of "steam-bath" heat and humidity. As a result, office buildings and many homes are air-conditioned.

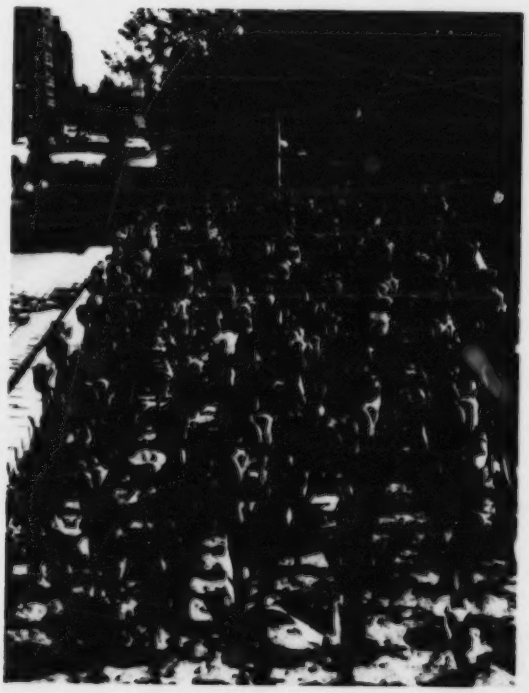
THE FOUR SEASONS

The normal seasonal progression in Toronto calls for cold to cool winters with periods of snow or rain and snow alternating with bright sun shine; the slow return of warmth in spring along with showery weather; periods of heat and humidity in summer accompanied by occasional thunderstorms; and increasing cloudiness, more frequent rains, and rapidly lowering temperatures during autumn.

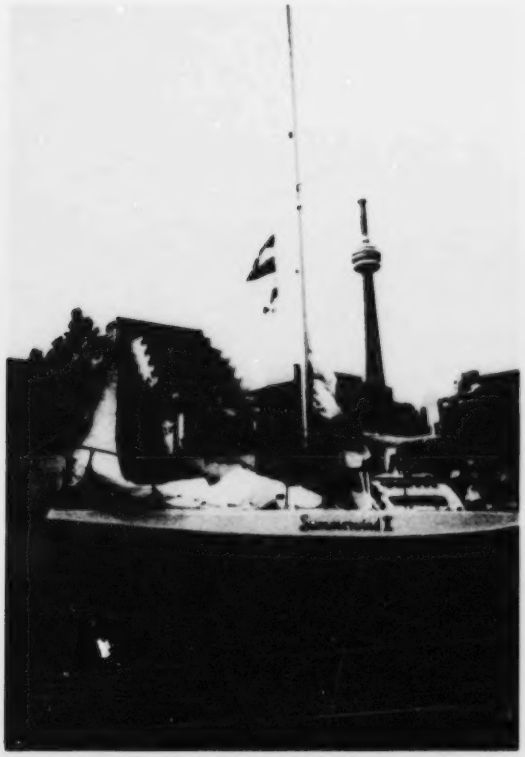
(Can. Wide)

Winter is the most variable of the seasons, with significant fluctuations in temperature and not infrequently strong winds. Almost half of the days have some measurable precipitation. Daily maximum temperatures during mid-season are normally just below the freezing mark. While temperatures can reach well above zero and precipitation may fall as rain, such mild weather is often short-lived. Normally, each winter brings a few episodes of freezing precipitation.

The transition from winter to spring usually begins about March and is a time when rainfalls are much more common than snowfalls, the snow cover disappears, and the ground gradually thaws and dries. Winter storms become less common. Temperatures can fluctuate considerably from maximum values near the low teens to spells below freezing.

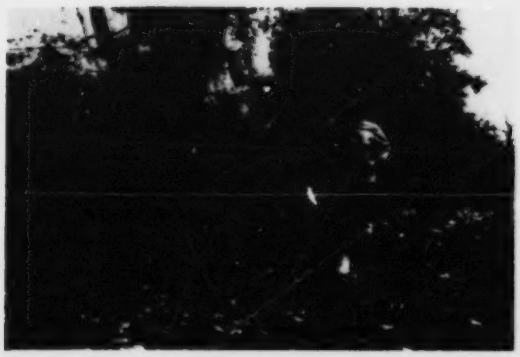


Spring lasts about 6 weeks during April and May. In the early stages of the season, fine weather often alternates with times of dull, wet weather. While significant amounts of snowfall are rare, snow-flurries can occur. Spring also marks the beginning of the thunderstorm season. The frost season ends in late April or early May, but the risk remains at some sites until late May.



Daylight hours lengthen rapidly during early summer, reaching almost 16 hours during the summer solstice on June 21. Maximum temperatures in summer can range from 20°C to above 30°C, with average values in the mid- to upper twenties. At times, very warm days are accompanied by high humidities and discomfort. Much of the summertime precipitation falls from brief thunderstorms or showers, with thunderstorms sometimes accompanied by hail, damaging winds, or even the threat of a tornado in the vicinity. Overcast, wet weather normally does not persist longer than a day or two.

September brings a transition from summer to autumn. It is a time when warm, fairly dry weather can be interrupted by intervals of cloudy and cooler weather. The first frost normally does not occur until October.



During autumn, the days rapidly become shorter and warm sunny periods become increasingly dominated by dull, rainy weather. Fog is common around sunrise during clear nights. Often, October is marked by a spell of sunny, warm weather known as "**Indian Summer**", when temperatures can reach into the twenties.

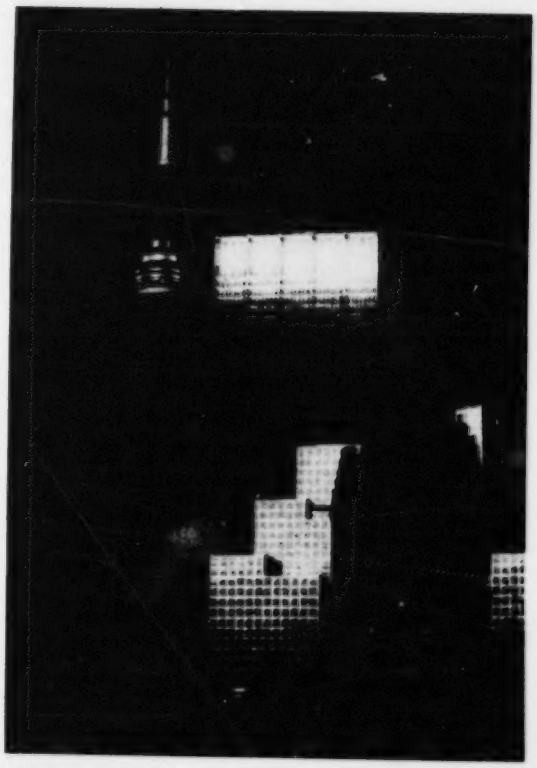
Weatherwise, the transition from autumn to winter is the dullest time of the year when periods of 5 days or more with little sunshine and frequent rain are not uncommon. Winter often begins after the passage of a particularly intense snow storm, when day-time temperatures dip below freezing. During December, the precipitation is more likely to be snow or even freezing rain.

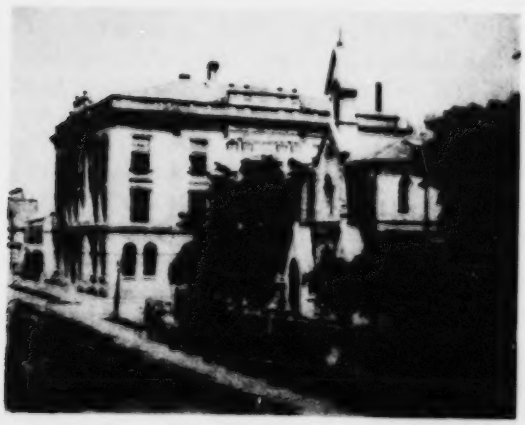
(Dave McCulloch)

SECTION I
CLIMATE INFLUENCES

CLIMATE OBSERVING STATIONS

References to past weather in Toronto can be found in the letters, papers, and diaries of the first settlers. While these reports help in understanding the weather of that period, most are too random in time and location to give a detailed picture of climate. However, the city is fortunate to have a continuous and long record of scientifically reliable weather reports at a site called Toronto - the oldest weather station in the country. To distinguish this station from others in the Metro area, it is referred to as Toronto (city) both in the text and presentation of data. The first weather records at Toronto (city) were taken early in 1840 at Fort York on the lakeshore. The site was located on the edge of "muddy" York, a small town with a population around 15,000. While the location has changed only slightly since then, the environmental setting around this climate station has undergone vast changes. Today, it is located in the core of the large metropolis of Toronto.





(M.T.R.L.)

Growth in Toronto has been rapid since its incorporation as a City in the mid 1830s. The climate of the city has gradually been altered by this growth, as natural areas have been transformed for human activities. Changes in the local climate have been particularly noticeable since World War II, when booming growth conditions brought massive urban development, changes in land use, as well as increases in industrial pollution and heat from buildings and transportation.

1955 (Ronald B. Crowe)

1982 (N.F.B.)

Because the Toronto (city) station is well-known, its weather reports are often used to represent the climate of Metro Toronto. However, a more detailed description of the climate can be obtained using climatic data taken at other sites in the area (see Figure 1). The majority of these sites, known as climatological stations, are operated by trained volunteers and cooperative agencies who measure precipitation amounts and temperature maxima and minima twice daily. Three of the stations shown in Figure 1 - Toronto Island A, Toronto Pearson Int'l A, and Toronto Buttonville A - are staffed by professional observers who gather more detailed information on a wide variety of weather phenomena. Toronto Pearson Int'l A is referred to simply as Pearson International Airport in both the text and presentation of data. Data collection at Buttonville Airport only began in 1986, so no analyses could be done with such a short period of record. These principal weather stations each maintain hourly observational programs. Toronto Downsview A, once also a principal weather station, no longer provides weather observations, since ceasing operation in the early 1980s. The measurements taken at climatological and principal weather stations are made using standard instruments and standardized observing procedures, allowing measurements to be comparable from one location to another.

Data from the weather stations can be used for several purposes. Values of weather parameters can be averaged to give a best estimate of mean weather conditions expected at various times of the year. These averages, usually calculated over a 30-year period, are known as climatic normals. A comparison of normals for various sites in an area can reveal local peculiarities in climate. Other users of climatic information may want to know how far the weather can depart from average. Extreme values of weather parameters, as observed in past, prove useful for indicating possible ranges. Mean and extreme climatic data for sites in the Toronto area are given in the appendices.

FACTORS THAT INFLUENCE CLIMATE

Toronto's climate is principally determined by its geography. The city's latitude and placement in east-central North America subject it to a **continental climate** that is considerably modified by the Great Lakes. Within the city, the climate is by no means homogeneous, but varies locally due to the influences of land-use and topography, especially distance from the lake.

Geographical Influences

Metro Toronto is located in a shallow basin opening south to Lake Ontario. The area stretches about 40

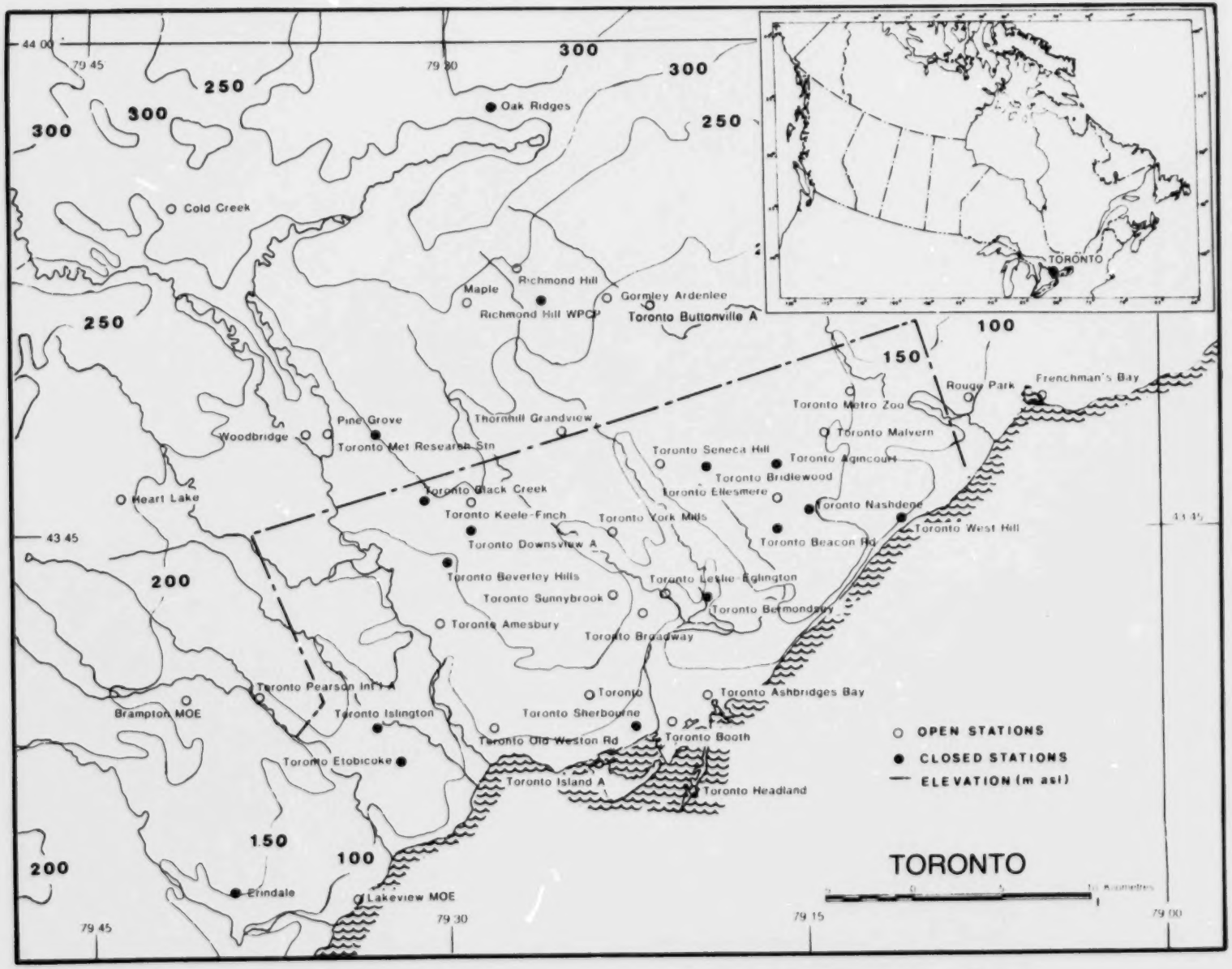


Figure 1. Topographic map of the Toronto area with locations of some climatological stations

km along the northwestern shore of Lake Ontario and extends northwards from the Lake for 15 to 20 km. Land elevations slope from 75 m above mean sea level at lake level to near 200 m at some sites to the north. East of the downtown core, cliffs known as the Scarborough Bluffs rise abruptly to some 70 m above the Lake.

Scarborough Bluffs (Peter Chen)

Toronto is located at a latitude subject to rapid passages of **weather systems**. These weather systems and their accompanying **air masses** usually move in an easterly direction across the continent, seldom lingering in the Toronto area for more than a couple of days.[1] This steady progression of air masses results in variable weather from day to day and a climate that shows big changes from year to year. The precipitation regime is relatively uniform from month to month.

Air approaching Toronto from any direction other than the north through eastnortheast comes under the influence of the Great Lakes. Lake Huron lies about 200 km to the west and northwest, Georgian Bay about 100 km northwest, Lake Erie 100 to 200 km southwest, and Lake Ontario contiguous to the city. (See Figure 1.) These large bodies of water significantly moderate the climate from the extremely continental one that would otherwise prevail. Winter temperatures average about 3 Celsius degrees warmer than those reported for other localities at the same latitude but without the Great Lakes. The lakes, with their lag in water temperature changes, delay the start of spring, prolong warmer weather in autumn, and delay the coldest period of winter until early February. The lakes also increase cloudiness and precipitation, particularly during autumn and winter, by adding moisture as well as heat to the cool air flowing over them.

Due to its proximity, Lake Ontario exerts the greatest influence on Toronto's climate. Because the Lake is deep, it is almost always ice-free and is relatively cool in summer (some 6 to 12°C cooler than the nearby land). Large temperature differences commonly occur between the shore and inland areas, especially in spring and summer. Winds generally are stronger near the Lake while, in summer, humidities are higher and thunderstorm activity slightly less frequent than farther inland. During May and early June, fog is prevalent near the Lake.

Local Influences

The climate of Toronto's downtown core differs from that of neighbouring suburban areas. The city core often experiences wind speeds that are reduced compared to more open suburban and lakeshore areas. However, funnelling due to tall buildings often causes locally very strong gusty winds at street level. Numerous studies have shown that night-time temperatures in cities tend to be higher than those observed over surrounding rural areas. This phenomenon, known as the "urban heat-island effect", is produced by heat release from build-

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[1] A discussion on weather systems, air masses, and the general atmospheric circulation can be found in Climate Canada, Hare and Thomas.

ings, machinery, vehicles, and even body heat from the more than two million inhabitants; day-time heat storage in concrete, asphalt, and other surface materials; and reduced heat loss at night from urban air pollution. The temperature differences due to these man-made influences are accentuated on cloudless nights with relatively light winds. During daytime hours or during windy conditions, the differences are barely detectable.

Topographical features, such as valleys, ridges, and parkland, create local differences in climate. Numerous valleys and ridges, generally oriented north to south, cover the Toronto landscape. In some cases, these valleys are very deep and can stretch up to one km in width. Within urban valleys, night-time temperatures generally are lower and fog slightly more frequent than at nearby higher sites. City parkland areas also experience lower night-time temperatures than built-up areas.

Table 1 summarizes the influence of some of these topographical features on various climatic elements.

TABLE 1

Influence of some local geographical features on climate

Geographical Feature	Climate Condition Affected			
	Temperature	Cloud/Fog	Wind	Precipitation
Near large bodies of water	higher in fall and winter; lower in spring and summer	more common than inland	stronger; less gusty in summer	less frequent in summer; more common in winter
Within valleys	possible cold air drainage at night; often higher summer maximums	more fog	channelled by valley	depends on valley size
Significant ridges and hills	lower	can be more common	stronger at top; quite variable	more common and heavier on windward side
Within forest and plant cover	lower maximums	nil	lighter	greater snow on ground and less melting in forest

(Ronald B. Crowe)

(Ronald B. Crowe)

SECTION II
CLIMATIC ELEMENTS

TEMPERATURE

To most people, temperature is the most important climatic element. Very high or low temperatures can cause human discomfort and, if extreme, can severely harm health or even cause loss of life. The annual temperature regime also plays an important role in determining the type and patterns of economic, recreational and sociological activities that take place through the year. Because of their significance, temperature statistics are used in many decisions, ranging from building design to the planning of outdoor activities.

Figure 2 shows normal and extreme temperatures recorded over the course of a year at Toronto City. The two inner curves depict normal daily maximum and minimum temperatures for any date, averaged over the 30 year period, 1951-80.

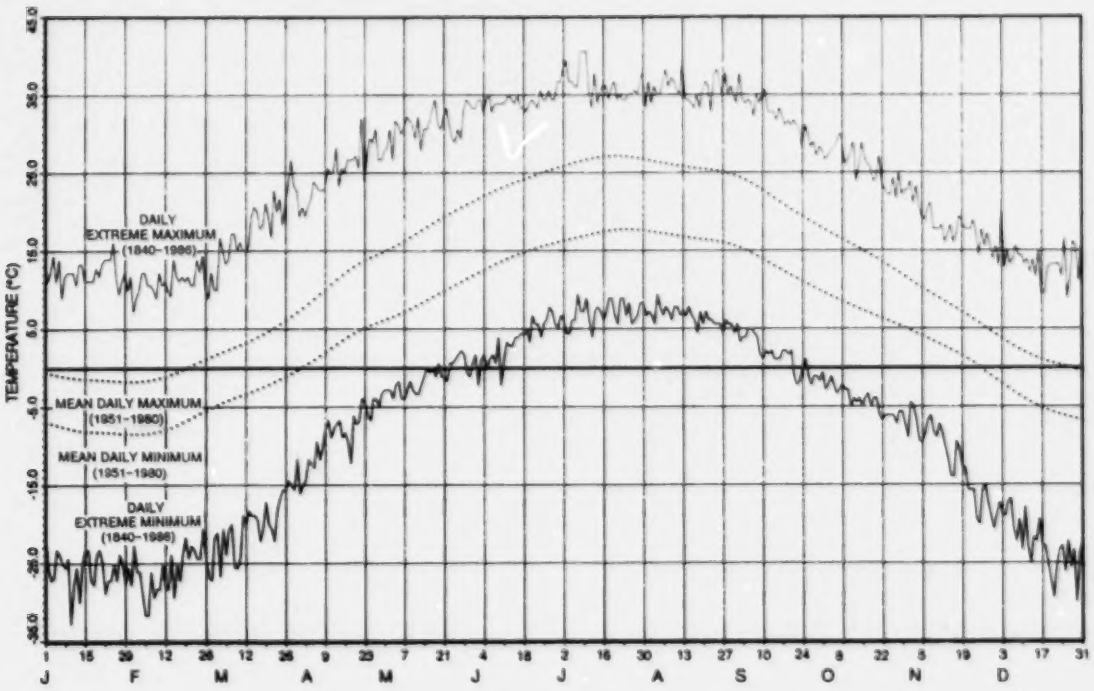


Figure 2. Mean daily and extreme temperatures at Toronto (city)

The warmest weather normally occurs around mid- to late July when daytime maximum temperatures reach 27°C on average. The coldest period occurs in early February when average minimum temperatures fall to -8°C. The outer curves depict daily extreme maximum and minimum temperatures for any date. These extreme value curves indicate a measure of the year-to-year variability of temperatures. Winter temperatures vary more from year to year than those in summer. In winter, it is fairly common to find daily temperatures that are several degrees higher or lower than normal values (as suggested by the greater difference between the mean and extreme value curves). While the lowest temperature on record at Toronto City occurred in January, 1859, at -33°C, temperatures have risen to values as mild as 16°C (1967) during the same calendar month.

The winter months are noted for large temperature ranges and occasionally, for large day-to-day temperature changes. On March 4, 1950, for instance, the temperature at Pearson International Airport rose from a minimum of -29°C to a high of 4°C, a difference of 33 degrees! April and early spring mark the beginning of the growing season. Hot weather can be experienced occasionally in May, when extreme maximum temperatures can climb to the 30°C mark or higher. Temperatures can become uncomfortably hot during mid-summer. The all-time highest temperature in Toronto, 41°C, occurred during July, 1936. Temperatures normally decline from mid-August onwards. By late September, the leaves often show signs of changing colour as temperature continues to fall steadily. Average night-time temperatures fall below freezing by early to mid-November, and daytime temperatures by mid-December.

Because of the urban heat island effect, average temperatures at Toronto City are higher than those reported outside of the city core. The magnitude of the temperature difference between urban and rural sites generally depends upon the population of the urban area. One experiment, described by Smith (1972), supported an average heat island of 2.6°C for the Toronto city core in 1971. In the period from 1841 to 1971, the heat island for the city increased from zero to 2.6°C as the population grew.

The Great Lakes significantly moderate temperatures. In mid-winter, near-shore surface water temperatures on Lake Ontario average slightly above freezing. By mid-summer, the average water temperature reaches near 18°C. As a result, sites close to Lake Ontario report, on average, temperatures slightly warmer in winter and cooler in summer than sites farther inland. During spring and some summer afternoons, a phenomenon known as a **lake breeze** can bring cool lake air inland to the downtown core and temperatures can be cooled by as much as 15°C, although average cooling is between 3 and 4°C. The lake breeze occurs 40 per cent of the afternoons in spring and early summer (Smith, 1972). Farther inland, the lake breeze occurs less frequently and with less cooling, rarely reaching localities as far as 25 km inland. During fall and winter, relatively mild air over Lake Ontario can warm temperatures near the shore as much as 8°C. The inland penetration of milder lake air normally is restricted to distances of 5 km or less.

In general, maximum temperatures are more uniform across the Toronto area than are minimum temperatures. Table 2 gives mean maximum and minimum temperatures by month for various climatic stations.

The consequences of local temperature differences can be significant. Sites near the lakeshore and

in the downtown core experience an average **frost-free period** of 191 days per year, while Pearson International Airport and outlying sites average 149 days - a difference of 42 days or 6 weeks!

While Toronto's daily temperature is generally quite variable, there are spells when airmasses stagnate over the area and temperatures persist above or below normal for a number of days.

TABLE 2

Mean daily maximum and minimum temperatures for various sites in the Toronto area (1951-80)

SITE	°C	MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Period of Record
Toronto (city)	max	- 1.3	- 0.5	4.1	11.7	18.2	23.7	26.7	25.6	21.3	14.7	7.8	1.4	1951-80
	min	- 7.9	- 7.2	-2.6	3.4	8.9	14.3	17.2	16.6	12.7	7.2	2.0	-4.6	
Toronto Downsview A	max	- 2.6	- 1.8	3.5	11.8	18.8	24.4	27.2	26.0	21.5	14.7	7.4	0.4	1956-80
	min	-10.3	-10.1	-4.6	1.5	7.4	12.6	15.6	14.9	11.1	5.3	0.3	-6.8	
Pearson Int'l A	max	- 2.5	- 1.6	3.3	11.5	18.4	23.9	26.8	25.8	21.3	14.6	7.2	0.4	1951-80
	min	-10.9	-10.5	-5.2	0.8	6.1	11.5	14.2	13.6	9.6	3.9	-0.6	-7.4	
Toronto Island A	max	- 1.7	- 1.5	3.2	9.9	15.9	21.5	24.7	24.1	20.2	13.4	7.3	1.1	1957-80
	min	- 8.1	- 8.1	-3.0	2.4	7.4	12.7	15.8	16.1	12.7	6.8	1.9	-4.8	
Toronto Met Res Stn	max	- 3.0	- 2.3	2.6	11.0	18.1	23.7	26.5	25.4	20.9	14.2	6.8	-0.3	1965-80
	min	-10.4	-10.0	-4.7	1.5	6.9	12.3	14.8	14.0	10.4	4.7	0.0	-6.8	

TABLE 3

Average number of occurrences of winter cold periods at Pearson International Airport (1951-80) with minimum temperatures of -15°C or colder

Duration in days	Month Dec	Jan	Feb	Mar	Average number of occurrences in winter
1	0.8	1.3	0.9	0.5	3.5
2	0.6	0.9	1.0	0.4	2.9
3	0.5	0.4	0.4	0.1	1.4
4 and over	0.2	0.9	0.6	0.1	1.8
Average frequency of cold spells of 3 days or more	0.7	1.3	10	0.2	

(Tor. Tel.)

Winter Cold Spells

A winter cold spell is defined here as a period of at least 3 days when minimum temperatures fall to -15°C or lower. Prolonged cold spells are significant, often resulting in curtailment of many outdoor activities and significantly increased heating and energy consumption.

While minimum temperatures normally fall below -15 C during 25 to 30 per cent of the days in winter at Toronto City, temperatures usually remain low only for one or two days. Cold spells lasting 3 days or more have occurred, on average, slightly more than 3 times each year in the period, 1951-80. Winter cold spells occur in January during more than 75 per cent of the years. There are some winters, however, when air masses change so frequently that spells of any sort fail to develop. The frequency of cold temperature periods of varying lengths are shown in Table 3.

Winter Mild Spells

Toronto also experiences periods of mild weather during the winter when temperatures exceed and remain at or above freezing during both day and night. In most cases, the mild weather only lasts for one and maybe two days.

While mild winter weather usually makes outdoor activities more pleasant, prolonged above-freezing temperatures can affect snow or ice surfaces negatively from a recreation point of view. A rapid transition from mild to very cold weather can cause considerable inconvenience to transportation when road surfaces become ice-covered.

Over the 30-year period (1951-1980), thawing weather of varying durations has occurred on average about 3 times each year at Pearson International Airport from mid-December to late February (see Table 4). Mild spells lasting 3 days or longer only occur one year in three and are most common during December and February.

(Tor. Tel.)

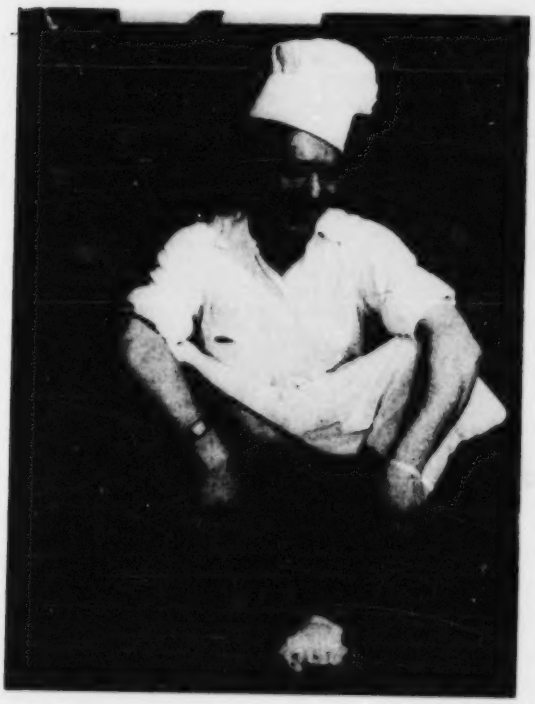
TABLE 4

Average number of occurrences of winter mild periods at Pearson International Airport (1951-80) with minimum temperatures at and above 0°C

Duration in days	Month			Average number of occurrences in winter
	Dec	Jan	Feb	
1	0.6	0.6	0.9	2.1
2	0.2	0.3	0.2	0.7
3	0.1	-	0.1	0.2
4 and over	0.1	-	-	0.1
Average frequency of mild spells of 3 days or more	0.2	-	0.1	

Summer Heat Waves

The Toronto area experiences an average of 6 hot days during the year when maximum temperatures reach or exceed 32°C. Often, these hot days alternate with cooler ones and give minimal discomfort. A string of hot days, however, can bring considerable discomfort and become quite significant in terms of health and cooling costs. Prolonged spells of hot weather, known as heat waves, often are accompanied by humid air and high overnight temperatures.



(Tor. Tel.)

A heat wave will be defined here as a period lasting 3 days or more when maximum temperatures reach at least 32°C. These heat waves occur, on average, seven times each decade. While some summers do not bring any heat waves, other summers can bring several. The earliest heat wave occurred during May, 1962 and was the only occurrence during this month in the 30-year period; although there may be hot days in May, heat waves are indeed rare. While more hot days occur in July (2.6 days), heat waves are only slightly more frequent during this month than in June or August. Table 5 indicates the frequency of summer heat waves at Pearson International Airport.

The longest heat wave in the Toronto area lasted 10 days during August and early September, 1953, and resulted in a few human fatalities from heat prostration. During early July, 1988, a five-day heat wave brought temperatures of 35°C or greater to Pearson International Airport.

(N.A.C.)

TABLE 5

Average number of occurrences of summer hot periods at Pearson International Airport (1951-80) with maximum temperatures at or above 32°C

Duration in days	Month					Average number of occurrences in summer
	May	Jun	Jul	Aug	Sep	
1	0.1	0.3	1.2	0.3	0.1	2.0
2	-	0.2	0.3	0.2	0.1	0.8
3	-	0.1	0.1	0.1	0.1	0.4
4 and over	-	0.1	0.1	0.1	-	0.3
Average frequency of heat waves of 3 days or more	-	0.2	0.2	0.1	0.1	

Summer Cool Spells

Cool days, when maximum temperatures reach values of 20°C or less, are uncommon during July and August. On average, slightly less than one such cool day occurs in July, while one or two cool days are normal for August.

Cool periods lasting 3 or more days only have occurred, on average, one year in six during July and August over the 30 year period, 1951-80. On rare occasions, Metro Toronto will experience long spells of cool weather in mid-summer. Most of these very cool summers occurred in Toronto City during the 1800s, before urbanization became significant. The longest spell of such summer cool weather lasted 6 days during August, 1851 and again during August, 1885. In recent history, August of 1979 was cool with the monthly maximum temperature averag-

ing 2°C below normal and a 5-day spell with daytime temperatures near or below 20°C.

Uncomfortable Weather

Extreme temperatures can create uncomfortable or even dangerous conditions. Uncomfortable conditions can also result in winter from windy weather with low temperatures or, in summer, from humid weather with high temperatures. Winter discomfort is discussed later (in this Section) under winds while summer discomfort is discussed under humidity.

PRECIPITATION

Adequate moisture is essential for many industries, marine transportation, and for hydro-electric generation. In the most ideal scenario, precipitation should supply a reliable and adequate amount of water without detracting from comfort and recreation.

(Tor. Tel.)

Toronto (city) receives an average of 801 mm of precipitation annually. This amount includes rainfall and frozen precipitation (664 mm) plus the water equivalent of all other forms of solid precipitation. For most climatological stations, mean total precipitation (mm) is roughly equal to total rainfall (mm) plus one-tenth of the total snowfall (cm). The one-tenth factor represents an average conversion needed to change snow amounts to water equivalent. For stations equipped with an instrument called a **snow gauge**, the total precipitation is equal to the total rainfall plus the actual measured (melted) water equivalent of the snowfall.

(A.E.S.)

Monthly mean precipitation amounts range roughly from 50 to 75 mm across Metro Toronto (Table 6 and Figure 3). February receives the least amount while the wettest months occur in the Spring, mid-Summer and early Winter. While precipitation amounts vary considerably from year to year and site to site, extremely dry or wet months are rare.

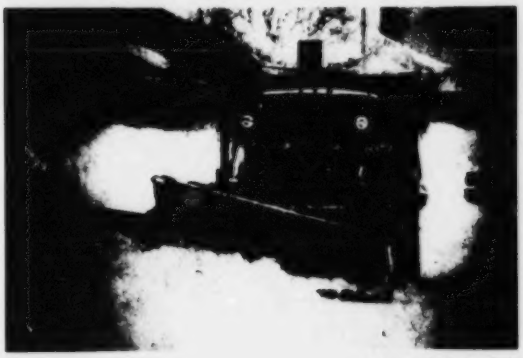
(Heather Auld)

The wettest year on record at Toronto (city) occurred in 1843, when 1308 mm of precipitation was reported. The driest year in recent history happened in 1958, when Pearson International Airport reported only 507 mm. For some stations, the wettest month on record occurred in October, 1954, when Hurricane Hazel

(N.F.B.)

tracked across Toronto. Over a 72 hour period, the storm brought a deluge of 276 mm of rain to Brampton, which lies northwest of Metro Toronto.

Although snowfall for Toronto (city) averages 139 cm, amounts have varied from as little as 47 cm during 1952-53 to as much as 314 cm in 1869-70. Snowfall amounts probably vary locally more than any other form of precipitation. Average annual totals range from 119 cm at Toronto Island Airport to as high as 158 cm in Richmond Hill, to the north of Metro Toronto. The greater snowfall in the north is due to their lower average temperature, resulting in precipitation falling as snow instead of as rain over a number of times during the winter when the temperature is close to the freezing point, and the fact that



(A.E.S.)

TABLE 6

Comparison of mean monthly precipitation amounts for various sites in the Toronto area

SITE	Element	MONTH													Period of Record
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
Toronto (city)	Precipitation (mm)	61	52	70	73	66	64	74	73	66	61	68	73	801	
	Rain (mm)	26	24	44	65	66	64	74	73	66	60	61	41	664	1951-80
	Snow (cm)	36	29	25	8	-	-	-	-	-	1	7	34	139	
Toronto Island A	Precipitation (mm)	56	48	60	67	63	67	71	71	70	57	64	72	764	
	Rain (mm)	25	24	38	60	63	67	71	71	70	56	59	42	644	1957-80
	Snow (cm)	31	25	21	7	Tr	-	-	-	-	Tr	6	29	119	
Toronto Downsview A	Precipitation (mm)	56	47	59	68	62	70	74	71	65	59	69	67	767	
	Rain (mm)	22	18	34	59	61	70	74	71	65	59	60	34	627	1956-80
	Snow (cm)	38	31	26	9	Tr	-	-	-	-	1	9	35	148	
Pearson Int'l A	Precipitation (mm)	50	46	61	70	66	67	71	77	64	62	63	65	762	
	Rain (mm)	21	21	37	62	66	67	71	77	64	61	55	36	637	1951-80
	Snow (cm)	33	27	22	7	Tr	-	-	-	-	1	8	33	131	
Richmond Hill	Precipitation (mm)	62	49	63	70	71	68	71	80	62	63	71	76	805	
	Rain (mm)	23	20	37	59	71	68	71	80	62	61	60	37	647	1959-80
	Snow (cm)	39	28	26	11	Tr	-	-	-	-	2	12	39	158	

Tr = Trace amount, not measurable

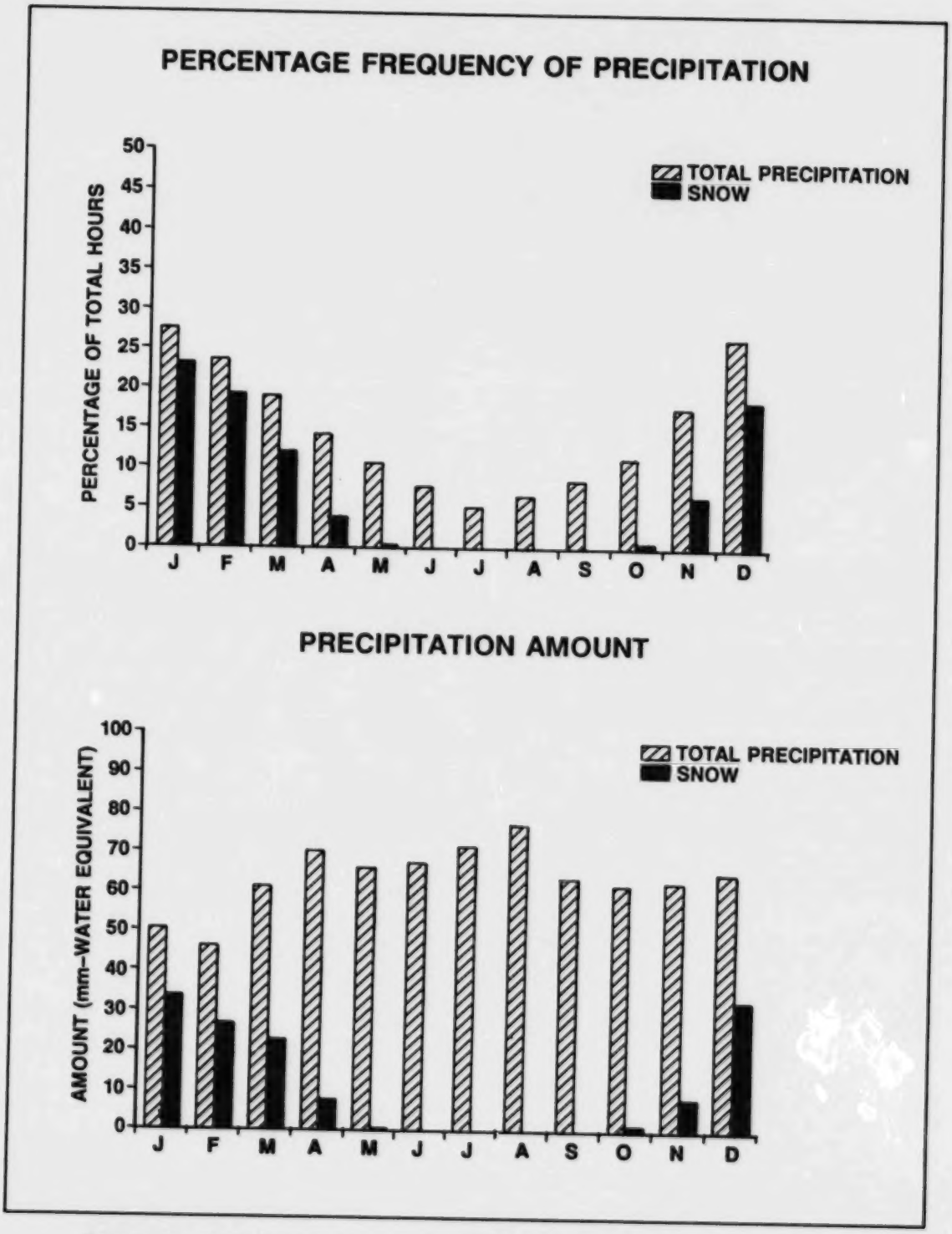


Figure 3. Percentage frequency (1953-82) and amount (1951-80) of precipitation at Pearson International Airport

the snowbelt region from L[illegible]e Huron and Georgian Bay sometimes extends to the northern fringes of the area.

Snow cover in Metro Toronto in highly variable from winter to winter. Although snow normally lies on the ground from late December or early January to early March, there is likely to be at least one complete thaw during mid-winter. Of course, the snow season lasts longer in the northern parts of the area. The earliest date with a snow depth of 4 cm or more was October 22, 1969, when a snowstorm brought 13 cm of snow to Pearson International Airport. The snowfall occurred at a time before most leaves had fallen from the deciduous trees and in fact, before the leaves had finished changing colour in the city core (Smith, 1972). The latest date with a measurable snow cover still remaining was April 26, 1976.

Freezing rain occurs when there is a shallow layer of cold air near the surface (below 0°C). The rain

(Ont. Hydro)

immediately freezes upon impact with exposed surfaces, forming an ice coating that can cause significant structural damage, particularly to trees and power lines. Freezing precipitation can also occur in the form of freezing drizzle, which is

TABLE 7

Mean number of days with measurable precipitation for various sites in the Toronto area

SITE	Days with	MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	Period of Record
Toronto (city)	Precipitation	14	12	12	11	11	10	9	10	9	10	12	14	134	
	Snow	11	9	7	2	-	-	-	-	-	-	3	9	41	1951-80
Toronto Island A	Precipitation	14	11	11	11	10	10	9	9	9	10	12	14	130	
	Snow	10	9	6	2	-	-	-	-	-	-	2	9	38	1957-80
Toronto Downsview A	Precipitation	15	13	13	12	11	11	10	10	10	11	13	15	144	
	Snow	13	11	8	3	-	-	-	-	-	1	4	11	51	1956-80
Pearson Int'l A	Precipitation	14	12	13	11	11	9	9	10	9	11	13	15	137	
	Snow	12	10	8	2	-	-	-	-	-	-	4	11	47	1957-80
Richmond Hill	Precipitation	16	13	13	13	12	11	9	11	10	12	14	17	151	
	Snow	14	11	8	3	-	-	-	-	-	1	5	13	55	1959-80

TABLE 8

Mean number of days with measurable precipitation of various types at Pearson International Airport (1953-82)

Precipitation Type	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Rain/drizzle	4	4	7	10	11	9	9	10	9	10	10	6
Freezing Precipitation	3	2	2	*	0	0	0	0	0	0	*	3
Snow	12	10	8	2	*	0	0	0	0	*	4	11
No Precipitation	17	16	18	19	20	21	22	21	21	20	17	16

* Less than one

less hazardous since the glaze ice accumulates slowly. On average, freezing precipitation is reported 10 times each winter at Pearson International Airport. Sites near Lake Ontario report less frequent freezing precipitation due to the influence of the relatively warm Lake in modifying shallow cold air near the surface.

Precipitation occurs more often in winter than in summer, as shown in Tables 7 and 8. Much of the summer precipitation falls from locally heavy showers and thunderstorms that may hit some sites in the area and miss others completely. As a result, the summer rainfall tends to be concentrated over smaller time periods (Figure 3). By contrast, winter precipitation can fall as a light flurry, as light snow lasting a day or so, or as a snowstorm with heavy snow and strong winds. Over the average winter, there are 47 days at Pearson International Airport when more than a trace of snow is reported (38 days at Toronto Island Airport).

Prolonged and Heavy Precipitation

Over the 30-year period, 1951-80, there have been an average of 15 days per year when precipitation amounts exceeded 15 mm. Normally, the days with heavier precipitation are confined to summer and autumn. Only one to two of these days have given snow accumulations in excess of 15 cm.

(Tor. Tel.)

Daily precipitation totals are not necessarily the best indication of wet weather. While a day with a heavy shower or an all-day rain can be inconvenient for outdoor activities, prolonged wet weather where precipitation falls on consecutive days and causes the ground to remain wet can be more significant. Such wet spells, defined as lasting at least one week with a minimum of 2 mm of rain per day, tend to be long-remembered. Wet spells that fit this definition only happen every couple of years, usually during spring or

(Ont. Hydro)

TABLE 9

Return-period rainfall amounts (mm) at Toronto (city) (1940-86)

Return Period Years	Duration				
	10 min	30 min	1 hour	12 hours	24 hours
2	13.3	20.7	25.2	42.9	47.9
5	17.9	29.0	34.5	55.4	61.2
10	21.0	34.5	40.6	63.8	70.0
25	24.8	41.4	48.4	74.3	81.0
100	30.5	51.6	59.9	89.9	97.4

Extreme reported rainfall amount (mm)

Station	10 min	30 min	1 hour	12 hours	24 hours
Toronto city (1940-86)	27.9	44.7	50.0	83.1	97.0
Pearson Int'l A (1950-86)	25.9	40.4	47.5	110.7	137.4

fall. These wet spells are not necessarily periods of prolific rainfall; about half have given total rainfalls less than 25 mm.

The frequency of heavy rainfall is especially important for engineers designing storm sewers, highway culverts, and other drainage facilities. Usually, heavy rainfalls in short periods of time are the result of thunderstorms. The frequency of occurrence of a given rainfall in a set period of time determines the average return period of that event. For example, a rainfall intensity of 25 mm in a 10-minute period has occurred, on average, once every 25 years at Toronto City, giving a return period of 25 years for a rainfall of this intensity. Table 9 gives the return periods for rainfalls of varying intensities at Toronto City. Local topography may cause significant variations across Metro Toronto in the frequency of these heavy rainfalls.

Dry Spells

Prolonged dry weather can create problems for both urban and rural dwellers. In an urban setting, dry weather can cause increases in water consumption that can only be maintained for a limited time before water rationing is required. While Toronto has never experienced the kind of drought problems that have occasionally hit the Canadian Prairies, there have been dry spells serious enough to become inconvenient. Dry spells will be defined as periods lasting at least 15 days without measureable rain and will be considered for the critical months from April through October, when the ground is thawed or thawing and when precipitation shortages have a more significant impact on water supplies.

Dry spells between April and October occur, on average, once every two years. The dry spells of greatest concern have been accompanied by abnormally high temperatures. The longest dry spell to hit Toronto City area lasted 34 days during late July and August, 1876. In 1988, many municipalities in Metro Toronto were required to invoke lawn watering restrictions during early summer. The restrictions followed a dry May and June and a dry spell from late June to July 9, which was also accompanied by several hot days.

WIND

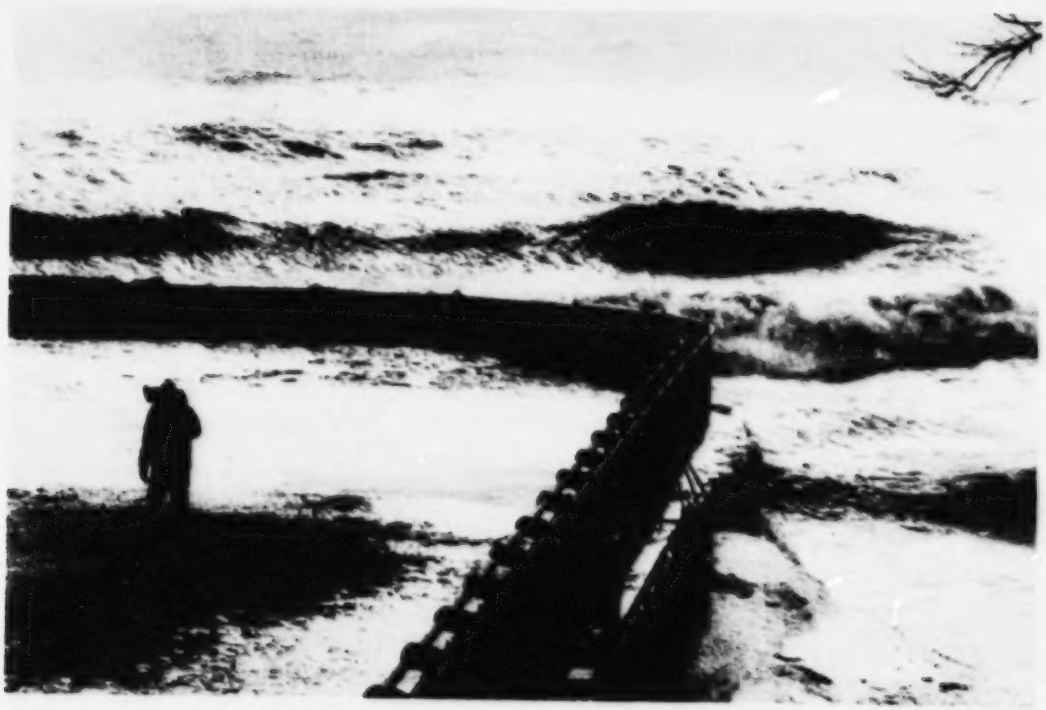
Wind is a weather element that enhances, moderates, and even modifies the effects of the other elements. A hot summer day, for instance, can feel more comfortable if accompanied by a cooling breeze. Alternatively, wind can make a cold day feel bitterly cold or can cause drifting snow or significantly reduced visibilities in blowing snow. Other times, changes in weather can be associated with shifts in wind direction.

Wind is essentially air in motion. Its speed and direction of flow are determined by atmospheric pressure patterns which, in turn, are linked to the weather systems crossing the area. Since weather systems tend to be more intense in winter than in summer, it is not surprising that the average wind speed in the Toronto area is greatest in winter.

Winds can also be influenced by smaller scale weather phenomenon, such as thunderstorms. Wind gusts as high as 200 km/h have been known to occur during severe thunderstorms. Locally, air can be forced to flow along a valley or away from a large body of water such as Lake Ontario. Within a city, winds can be alternately funnelled and blocked out by the combination of rectangularly arranged streets and high rises, often resulting in turbulence with whirlwinds and gusts.

Wind speeds are measured at a

(Globe)



(Globe)

standard height of 10 metres and represent an average value observed over a two-minute period. The wind gusts given in weather reports are extreme speeds measured over an instant. Wind speeds averaged over a two-minute period are considered fairly representative of the broad scale (non-local) winds, while wind gusts can vary considerably from site to site.

Average wind speeds of 20 km/h or less are described as light. When winds become moderate with speeds of 21 to 40 km/h, dust and loose paper swirl about, crested wavelets form on lakes, and fine loose snow begins to drift. Strong winds with speeds of 41 to 60 km/h cause large tree branches to move, give extensive drifting of snow, and create inconvenience for people walking against the wind. At 61 to 90 km/h, gale force winds break twigs from trees, give slight structural damage to buildings, and significantly reduce visibilities in blowing snow.

Winds at Toronto Island Airport, which is more representative of sites near Lake Ontario, behave somewhat differently from those at Pearson International Airport. (See Tables 10 and 11.) Average wind speeds at Toronto Island Airport reach higher values than those at Pearson International Airport from October to April as a result of air interacting with the surface of Lake Ontario. Prevailing wind directions near the Lake display a seasonal pattern, as shown in Table 10. In winter, sites near Lake Ontario experience westerlies that are stronger than easterlies. Farther inland at Pearson International Airport, the strongest winds year-round are associated with fairly common westerly to northerly winds.

In general, unstable air masses generate stronger, more gusty winds than do stable ones. During autumn and winter, cool air over the relatively warm surface of Lake Ontario becomes unstable, giving stronger and more gusty winds than farther inland. By summer, the Lake becomes relatively cooler than adjacent land areas and wind speeds become similar to those over land. Frequently, inland sites report day-time winds in spring and summer that are stronger and gustier than those at night; during the day, air over these sites becomes unstable from "strong" heating of the ground by the sun.

The highest wind speeds recorded in the Toronto area have usually

TABLE 10

Prevailing wind directions at Pearson International Airport and Toronto Island Airport

Station	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pearson Int'l A (1955-80)	SW-W* N	N* W*	N* W	N* NNW	N* NNW	N* W	N* W	N* W	N* W	W* N	WSW-W*	WSW-W* N
Toronto Island A (1957-80)	WSW-W*	W* NNW	E* W	E* NNW	E* W	E*	E* S W	E*	E* W	E* W	W* E	WSW-W*

* Direction with the greatest frequency

TABLE 11

Mean wind speed (km/h) at Pearson International Airport and Toronto Island Airport

Station		MONTH											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pearson Int'l A (1955-80)	Mean	18	18	18	17	15	13	13	12	13	14	17	17
	Max. gust	(115)	(97)	(124)	(111)	(98)	(102)	(89)	(93)	(92)	(96)	(97)	(95)
Toronto Island A (1957-80)	Mean	24	21	21	20	16	14	13	13	15	18	21	22
	Max. gust	(126)	(101)	(108)	(107)	(91)	(93)	(100)	(97)	(104)	(97)	(93)	(107)

been associated with winter storm passages. The highest average wind speed occurred on March 5, 1964 when speeds reached 121 km/h at Toronto Island Airport as a storm moved through the area. A raging winter storm struck Toronto on January 26, 1978, giving average winds of 90 km/h at Toronto Island Airport with gusts to 126 km/h. During this storm, air pressures plunged to an all- time low of 94.15 kiloPascals, while skyscraper windows popped and traffic slowed. In summer, the strongest winds are reported in thunderstorms. The highest gust ever reported in summer reached 134 km/h at Pearson International Airport on July 1, 1956.

Wind Chill

While the cooling ability of the wind may be appreciated on a hot summer day, winds acting in combination with cold temperatures can create uncomfortable or even dangerous conditions in winter. A measure called the **wind-chill** index can be calculated, accounting for the combined effect of wind and temperature. Wind-chill, which measures the rate at which heat is lost from an exposed object, can be expressed in units of watts per square metre (W/m^2) or **equivalent wind-chill temperature** (see Table 12). An average wind chill of 1600 W/m^2 has been found to freeze unprotected skin over a prolonged exposure period and indicates conditions where heavy outdoor clothing becomes mandatory. A wind chill of 1900 W/m^2 can freeze unprotected skin in about one minute with direct exposure. When the wind chill reaches 2300 W/m^2, conditions for outdoor travel (such as walking) become dangerous and exposed areas of the face freeze rapidly.

Wind chill in Toronto is most severe during or following a significant winter storm. During these times, wind directions are typically west, northwest, or north. The potential for frostbite, when the wind chill exceeds 1600 W/m^2, is greatest in January and February when these conditions occur on about 8 and 6 days of the month, respectively. A wind chill in excess of 1900 W/m^2 is rare. Table 12 indicates the normal percentage occurrence of various wind-chill classes at Pearson International Airport.

In the Toronto area, wind chills are similar for most localities. While temperatures are generally lower outside of the city core and away from Lake Ontario, wind speeds at these sites often are less. In the downtown core, wind-chill effects are complicated and aggravated by sometimes variable and gusty winds.

TABLE 12

Average number of days per month that the wind chill lies within specific ranges at Pearson International Airport (1953-82)

Wind chill (w/sq. m)	Equivalent Temperature (°C)	Comments	Month			
			Dec	Jan	Feb	Mar
less than 1200	above -15°C	Comfortable	10.9	5.6	6.2	14.4
1200-1399	-15°C to -22°C	Unpleasant for outdoor activities on overcast day	9.8	7.9	8.2	9.5
1400-1599	-22°C to -38°C	Unpleasant in any weather	7.1	9.2	7.7	5.5
1600 and over	below -38°C	Exposed skin will freeze	3.2	8.3	6.2	1.6

HUMIDITY

When describing an uncomfortably hot summer day, many Torontonians have either heard or used the phrase, "It's not the heat, it's the humidity". As the statement suggests, humidity is significant in determining human comfort. Humidity, which is a measure of the amount of moisture held in the air in the form of invisible **water vapour**, is also important in determining the drying power of the air and the likelihood of dew or fog formation.

Relative humidity is the most common expression used to quantify humidity. For a given amount of moisture, relative humidity is higher at lower temperatures when the air is closer to saturation than it is when the temperature of the same air rises. As a result, relative humidities in Toronto decrease in summer and increase in winter (see Table 13). Relative humidities often are highest in the early morning when temperatures fall to their minimum values.

Because of its temperature dependence, relative humidity is not the best indicator of the air's actual moisture. While relative humidities are useful in indicating the drying power of the air and the likelihood of fog formation, the **dew point temperature** is a better indicator of moisture. In Metro Toronto, dew point temperatures average a relatively low -8°C to -10°C during winter, then increase during spring as the air moisture increases, peaking at values around 15°C in July and August. During winter, the air contains significantly less moisture, even when saturated, and humidifiers often must be used in homes. When relatively dry winter air is heated to around 20°C inside houses, it's small moisture content can produce very low indoor relative humidities and uncomfortably dry conditions unless a humidifier is used.

Humidities at Toronto Island Airport are slightly higher than those in the city core or at Pearson International Airport during the summer months, when Lake Ontario adds extra moisture to the air (see Table 13). The humidity difference between Toronto Island Airport and inland sites is greatest during the daytime.

TABLE 13

Mean mean relative humidity and mean dew point temperature by month at 1 p.m. EST

Pearson International Airport (1953-82)

Humidity	MONTH												YEAR
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Dewpoint Temperature (°C)	-9	-8	-4	1	7	12	14	14	11	6	1	-5	3
Relative Humidity (%)	76	74	70	59	55	57	54	57	60	63	72	78	65

Toronto Island Airport (1957-82)

	MONTH												YEAR
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Dewpoint Temperature (°C)	-8	-8	-4	0	6	12	15	16	12	6	1	-5	4
Relative Humidity (%)	71	70	69	62	64	66	66	67	68	69	72	74	68

TABLE 14

Average number of days per month that the humidex lies within specific ranges lasting at least one hour at Pearson International Airport (1953-82)

Humidex (°C)	Comments	Month				
		May	Jun	Jul	Aug	Sep
30 - 34	Uncomfortable for some	2.4	6.0	9.4	9.0	3.6
35 - 39	Uncomfortable for many	0.5	2.6	5.3	4.2	1.6
40 and over	Widespread discomfort	-	0.6	1.2	0.8	0.3

Humidex

An index, known as the "**humidex**", considers the role of humidity in human discomfort during very warm days. The higher the humidex index, the greater the discomfort felt. Humidex values below 30 generally indicate comfortable conditions. Values reaching the upper 30's indicate uncomfortable conditions for most. When values reach 46 and above, activity for most people becomes difficult, many types of labour must be restricted, and some factories may close. The relation between humidex and comfort is quite subjective and can vary significantly with acclimatization, age, state of health, and physical condition of the person involved.

The highest humidex value at Pearson International Airport, 48°C,

was experienced on September 1, 1953, when the temperature reached 36°C with a dew point temperature of 25°C. Such high humidex values are quite rare, although values do reach at least the high 30s most summers. On average, values of 40°C or greater can be expected on 2 to 3 days per summer (see Table 14). Values between 30° and 40°C are experienced on 13 to 15 days per month through July and August, with discomfort occurring occasionally in May and September.

Fog

Saturated air can lead to the formation of fog. Fog consists of minute water droplets suspended in the air near the earth's surface (a cloud at the ground). When visibilities are reduced to 1 km or less, the condition is called moderate or thick fog. Light fog, by definition, restricts visibilities to 4 km or less.

One of the most favourable setups for fog formation occurs under night-time clear skies, light winds, and a moist airmass. The most common time for its formation is during the pre-dawn and dawn hours, when night-time temperatures fall to the dew point temperature. Fog that forms overnight often dissipates during the day with added heating from the sun; as a result, fog occurs less frequently during the late afternoon period. The most common times of the year for this phenomenon are the late winter to early spring and the late summer through autumn periods. One memorable fog incident, later renamed the "fog bowl", happened on December 1 and 2, 1962, when dense fog covering the area forced the famous Grey Cup football game to be played over the course of two days - the longest game in Grey Cup history. The fog was so thick that spectators in the upper stands couldn't see the other side of the playing field. Fans knew something was happening only when they heard the cheers from the other side of the stadium (Environment Canada).

Fog occurs more frequently at Pearson International Airport than

TABLE 15

Average number of occurrences per month of fog of various durations restricting visibilities to 4 km or less

Pearson International Airport (1953-82)

Fog Duration	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1 hour or more	13	14	16	14	14	14	13	18	18	18	20	16
3 hours or more	8	8	10	8	8	9	9	11	11	12	14	9

Toronto Downsview Airport (1956-82)

Fog Duration	MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1 hour or more	10	10	10	9	9	8	8	12	13	13	14	11
3 hours or more	7	7	7	7	7	6	6	8	10	11	11	9

at Toronto Downsview Airport, as indicated by Table 15. In spring and summer, fog banks are commonly seen over Lake Ontario, caused by warm, humid air coming in contact with the relatively cold lake waters. During spring, in particular, the fog may drift inland to reach the downtown core.

SUNSHINE AND CLOUD COVER

People spending at least some of their day outdoors usually notice whether the sun is shining or is hidden by cloud. The amount of sunshine that filters through can add and sometimes detract from outdoor comfort. By definition overcast conditions occur when more than 90 per cent of the sky is covered by clouds. When the sky is more than 50 per cent but less than 90 per cent cloud covered, it is cloudy. Finally, when the sky is 50 per cent or less cloud covered, the sky conditions are described as mostly clear. Cloudy skies generally allow some sunshine to reach the ground.

In the Toronto area, winter skies normally are either mostly clear or overcast (see Figure 4). During summer, sunny and partially cloudy skies are evident nearly one-half and one-third of the time, respectively. Overcast skies become increasingly frequent in autumn and normally can be expected 45 to 50 per cent of the time in November and December, when weather systems frequently cross the area.

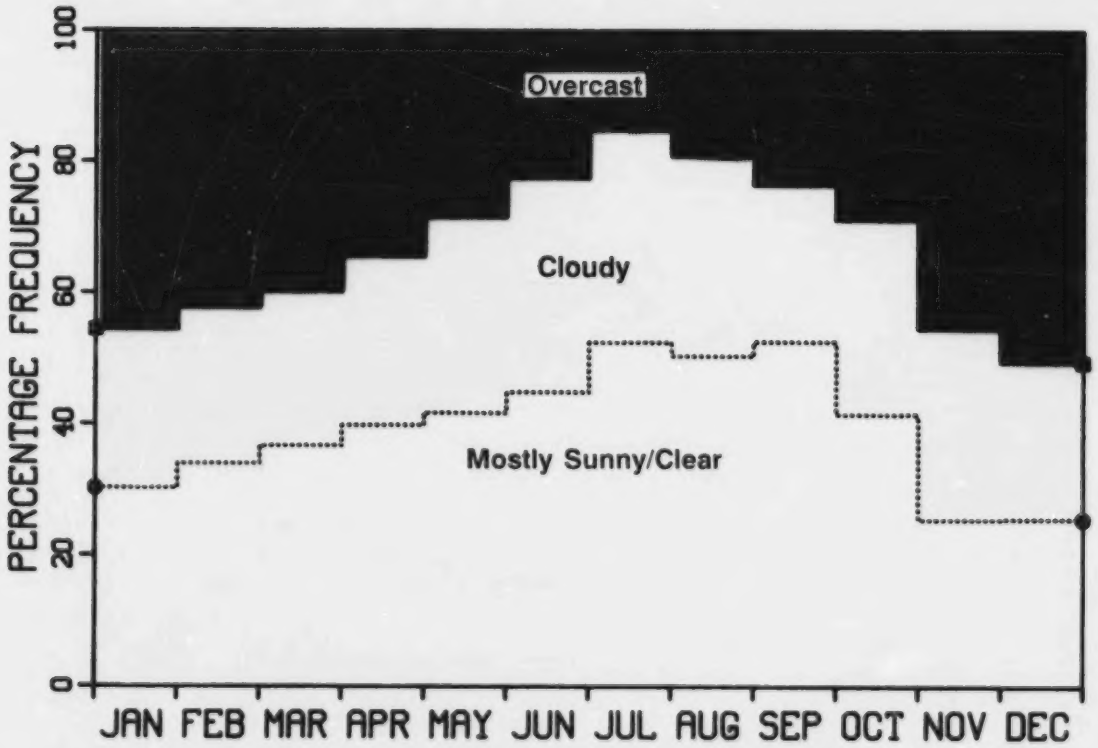


Figure 4. Cloud cover at Pearson International Airport (1953-82)

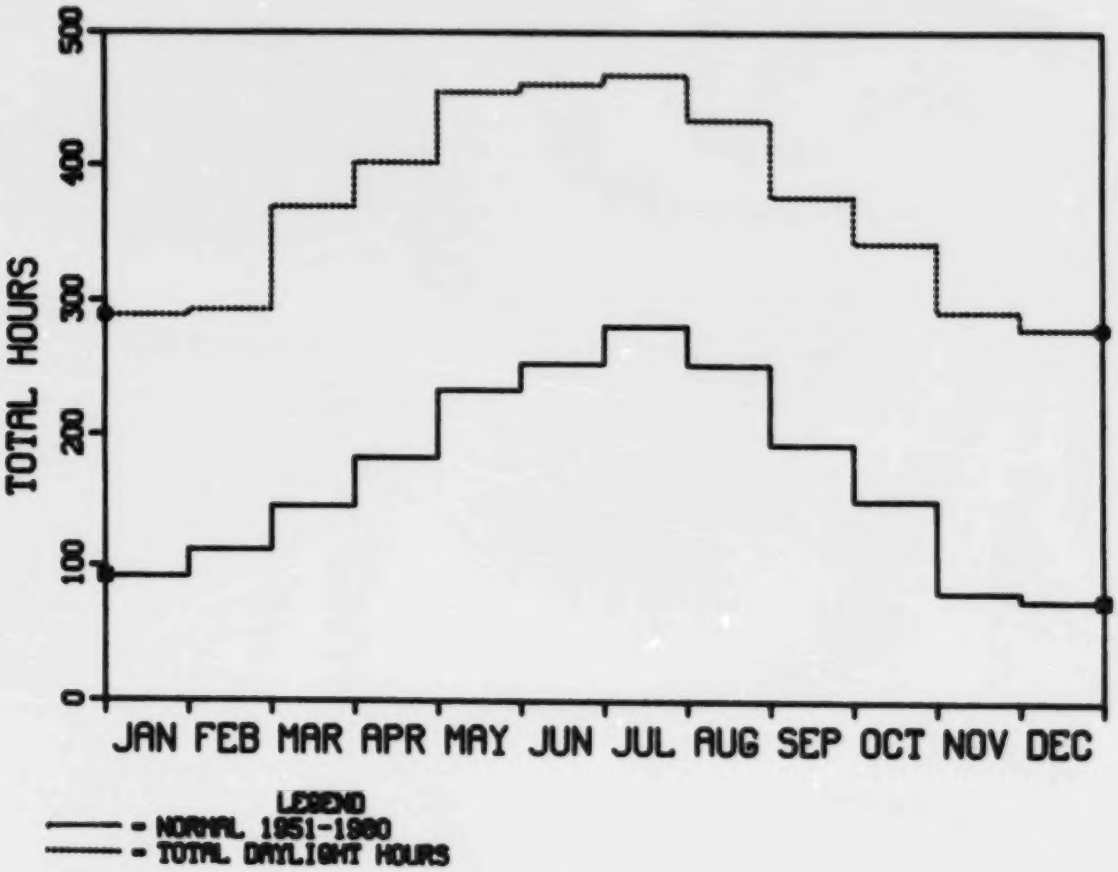


Figure 5. Mean hours of bright sunshine at Toronto (city) (1951-80)

Sunshine naturally increases in summer because the sun is above the horizon almost twice as long as it is in early winter. More important, though, is the fact that the sun shines more frequently in summer as the occurrence of overcast conditions decreases significantly. The average monthly hours of bright sunshine at Toronto (city) is shown in Figure 5. The solid curve illustrates the combined variation of daylight hours and cloud cover. The broken curve indicates total daylight hours for the month.

Sunshine and warmth are not necessarily related in the same way throughout the seasons. Sunny weather in winter often accompanies cold arctic air masses over the region. In spring and summer, the relationship reverses itself with higher daytime maximums usually accompanying sunny days.

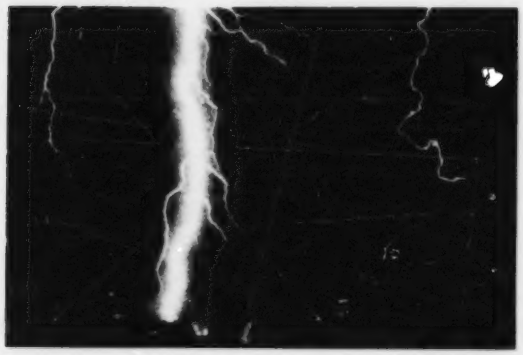
SEVERE WEATHER

Storms that are intense enough to stop most outdoor activities, damage property, or endanger human lives are classed as severe. In summertime, these severe storms include tornadoes, severe thunderstorms, and hurricanes while, in wintertime, they include heavy snowfalls (snowstorms), blizzards, and freezing rain storms.

Tornadoes and Severe Thunderstorms

A well-developed tornado probably contains the greatest concentration of atmospheric power on

earth. While tornadoes are local - only affecting small areas - their property destruction can range from slight to almost complete. These violent storms arise from severe thunderstorm outbreaks and can be distinguished by a narrow and rapidly rotating funnel or rope-like cloud extending downwards from a parent thunderstorm. When the funnel touches the ground, it can bring great destruction to life and property due to its very strong winds, flying debris, and a greatly reduced atmospheric pressure adding an explosive effect.



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During the 10-year period, 1970-1979, a total of 145 confirmed tornadoes touched down in Ontario (an annual average of 14.5 tornadoes). Recent updating of the statistics suggests that the annual frequency is higher, possibly due to improved detection and awareness of their existence. The majority of tornadoes occur in southwestern Ontario and west of the Toronto area. Although weak tornadoes have touched down within the boundaries of Metro Toronto, the city core has never been on the path of a well-developed one. One estimate (Newark) gives the odds of a damaging tornado hitting Metro Toronto as once every 20 years. Tornadoes are possible at any time of the day, but most occur during the afternoon and early evening and during the months from May through August.

In recent years, several tornadoes have struck Mississauga on the western outskirts of Metro Toronto. For example, a tornado on July 7, 1985, caused 10 injuries and property damage of 400 thousand dollars. At about the same time, the severe thunderstorms bringing destruction to Mississauga forced a 90 minute delay of the Canadian Open at Glen Abbey golf course (farther southwest near Oakville), when torrential downpours left the course a series of lakes and streams. Another tornado struck Mississauga on July 24, 1986, causing some property damage but no injuries. On August 14, 1984 a tornado hit northern Metro Toronto, causing an estimated 20 million dollars worth of damage to several buildings.

Thunderstorms occur most frequently during June, July, and August, with an average of 5 to 6 thunderstorm days per month. Thunderstorm activity is slightly suppressed by Lake Ontario, with the result that 4 to 5 thunderstorm days are normal near its shores. Only a fraction of thunderstorms produce severe thunderstorms, hail, or tornadoes.

Severe thunderstorms can cause significant damage due to large hail, strong wind gusts, and flooding. On the afternoons of August 27 and 28, 1976, for example, eastern Toronto was struck by severe thunderstorms which produced flooding and damages costing 2 million dollars. In 1981, a week of severe thunderstorms ended on August 19 with a very damaging storm north of Toronto. The storm produced "tennis-ball" sized hail that broke windows, stripped gardens, and damaged roofs. Total damage was estimated at several millions of dollars.

Hurricanes

The hurricane is a very intense

type of tropical storm. In Canada, these storms are known for bringing violent winds and torrential rain, mainly to Atlantic Canada and particularly during autumn. On rare occasions, southern Ontario has felt their effect. On average, hurricanes or their remains only brush southern Ontario every few years, usually bringing winds not strong enough to cause significant damage and heavy rains no greater in intensity than heavy thunderstorm downpours. One hurricane of above average intensity, Hurricane Hazel, struck the area on October 15-16, 1954. This storm tracked from the eastern Carribean Sea northwards, passing over Toronto on October 15. Extreme wind speeds were reported as high as 90 km/h with gusts to 115 km/h. Torrential rain giving accumulations in the order of 200 mm produced serious flooding in the rivers and creeks. The destruction was most severe in the Humber River Valley, where more than 80 fatalities and property damage amounting to some 24 million dollars resulted. The damaging consequences of the hurricane later prompted municipalities in Metro Toronto to actuate a very successful program of improved flood plain management.

Winter Severe Weather

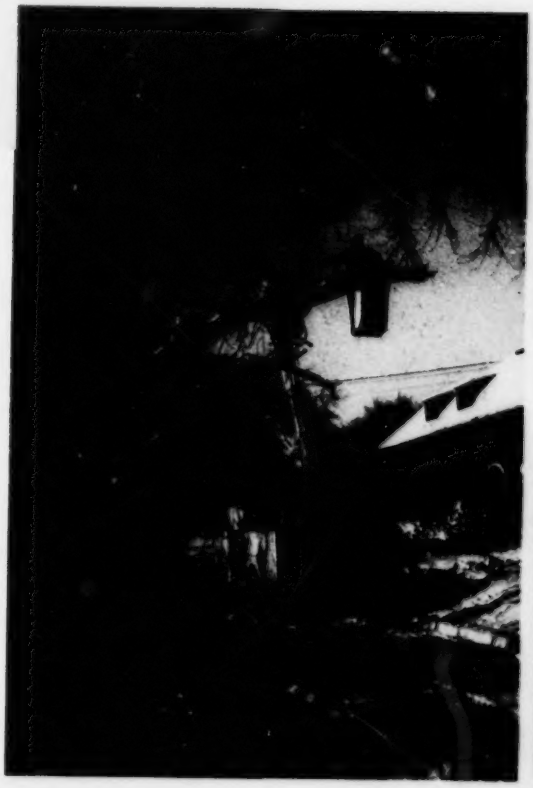
Winter severe weather usually results from large scale weather disturbances. The severity of the weather depends upon the temperature; form, intensity and duration of the precipitation; strength of the winds, and the depth and condition of the snow prior to the storm. The Toronto area usually experiences one or two snowstorms a winter when snowfalls exceed 15 cm, often accom-

Hurricane Hazel (Tor. Tel.)

Hurricane Hazel (Tor. Tel.)

panied by blowing and drifting snow. On January 26 and 27, 1978, a vicious "blizzard" struck Toronto giving 16 cm of snow to Toronto City, winds gusting to 90 km/h, and visibilities reduced to near zero in blowing snow. The storm closed many roads in the vicinity, resulted in over 400 injuries, and caused one woman to die from exposure when she became lost near Pearson International Airport. Costs due to closures, damages, and injuries for southern Ontario from the storm were estimated at over 41 million dollars.

Freezing precipitation storms represent another of Nature's winter menaces. Although the majority of freezing rain episodes only last a small number of hours, Pearson International Airport and sites in north Metro Toronto can average about 3 days a season with a freezing precipitation episode lasting 4 hours or more. One very persistent ice storm on December 27, 1959 brought 30 mm of freezing rain to localities just northwest of Metro Toronto and lasted over 32 hours. Sometimes, a dramatic drop in temperatures after mild winter weather can create conditions as dangerous for motorists as a freezing rain storm. On December 9, 1986, a total of 11 mm of rain fell on Metro Toronto only to be followed by a "fast freeze" during the evening rush hour. The result was slippery roads with hundreds of accidents, scores of injuries, and two fatalities.



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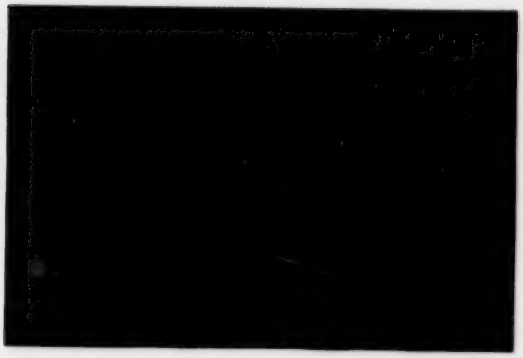

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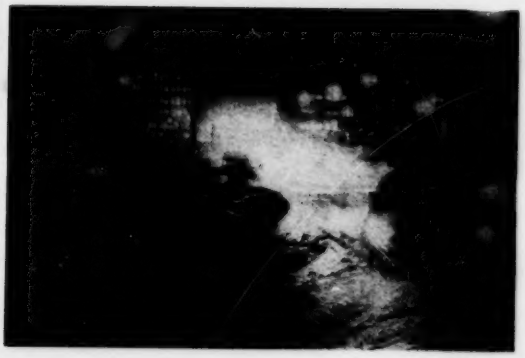

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SECTION III
THE CLIMATE AND HUMAN ACTIVITIES

Few can deny the significance of climate. Sometimes, it only takes a deviation from the normal climate, such as an unusually wet or cold spell, to bring about a respect for its importance.

Climate must be considered in designing buildings. For example, the National Building Code (National Research Council of Canada, 1990) requires that climatic information be used when determining the heating and cooling systems for buildings and in deciding the design and materials needed to protect against structural damage from strong winds, snow loads, moisture penetration, and other weather induced hazards.

Climate affects almost every outdoor activity that takes place. Tourism and outdoor recreational activities, for example, should be planned using climatic information before a site or activity can be developed. Agriculture is very strongly weather-bound. Crop yields and varieties, as well as animal

TABLE 16

Average and extreme frost-free period for various sites in the Toronto area

Site	Average			Extreme		Period of Record
	Last Spring Frost	First fall Frost	Frost-free Period (days)	Longest Frost-free Period (days)	Shortest Frost-free Period (days)	
Toronto (city)	Apr 20	Oct 29	191	219	103	1940-1980*
Toronto Downsview A	May 4	Oct 16	164	194	121	1956-1980
Pearson Int'l A	May 8	Oct 5	149	195	117	1938-1980*
Toronto Island A	Apr 21	Oct 30	191	218	166	1957-1980
Toronto Met Res Stn	May 13	Sep 29	138	158	91	1965-1980
Richmond Hill	May 7	Oct 5	150	185	119	1959-1980
Lakeview MOE	May 4	Oct 13	161	194	125	1963-1980

* Average values calculated for period 1951-1980 only

health and productivity, are at least partly determined by average and day-to-day weather. Even human health is affected by climate with certain diseases, health problems, and human psychological reactions linked.

Only a few of the many influences of climate on human activities can be reviewed in this publication. The impacts that will be considered include those on gardening, heating and air conditioning, and recreation and tourism.

GARDENING

For many plants, the growing season is determined by the dates of the last significant **frost** in the spring and the first in the fall. Knowledge of the frost-free period is helpful in deciding when it is safe to grow tender crops such as beans, corn, and tomatoes and when blossoms and fruit are less likely to be damaged by frost. The last spring frost occurs, on average, during late April in Toronto (city) and sites near Lake Ontario and as late as mid- to late May in agricultural areas to the west and north of the Toronto area. (See Table 16). The first frost in fall normally occurs during early October in rural areas surrounding Toronto, but is delayed in the city core and near the Lake until late October and sometimes even until November.

The frost-free period averages 191 days at Toronto City and near the lakeshore. Away from the water, the frost-free period rapidly drops off to an average of 164 days at Toronto Downsview Airport and to 150 days in Richmond Hill, north of Toronto. The shortest frost-free period at Toronto (city) lasted only 103 days in 1842 while the longest lasted 219 days in 1951. The dates of the first and last frost and the length of the frost-free period differ considerably from year to year.

(Can. Wide)

Meteorological factors other than the length of the growing season affect the growth and survival of plants. Indices of plant hardiness have been derived by Agriculture Canada to classify the suitability of Canada's climatic conditions for the growth of various woody ornamentals. These indices are converted to plant hardiness zones in Figure 6. The hardiness zones, as shown for southern Ontario, are derived from a formula that considers several meteorological factors affecting plant survival, the most important being the minimum temperature during winter. Other important factors are the summer rainfall, maximum temperatures, length of the frost-free period, snow cover, and wind.

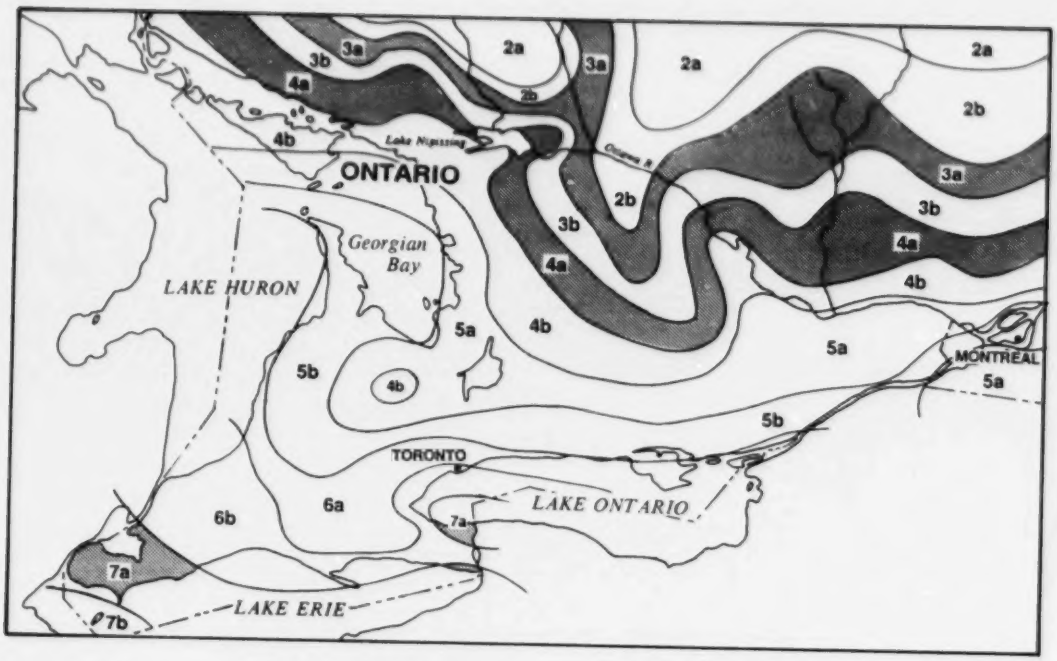


Figure 6. Ornamental plant hardiness zones in southern Ontario (Agriculture Canada, 1981)

Ten zones delineate ornamental plant hardiness in Canada. A zone identified as zero indicates coldest conditions while zones associated with higher digits indicate milder or less harsh conditions. Areas to the north of Toronto lie in hardiness sub-zone, 6a, while milder sub-zone, 6b, prevails closer to Lake Ontario. Ornamental plants rated for hardiness zone 6 or lower normally survive in Toronto's climate. Sometimes, smaller hardiness areas exist within a zone due to variations of the existing climate, but are too small to locate on the map. The milder conditions of downtown Toronto, for example, might approximate such an area, allowing the survival of some plants suited to zone 7a.

Climatic conditions in Toronto are similar to much of southwestern Ontario in terms of suitability for ornamental shrubs. Only the extreme southwestern tip of the province (near Windsor) experiences milder conditions. Climate and conditions for plant survival become progressively harsher north of Toronto. Compared to the rest of Canada, Toronto's climate is considered similar to coastal Nova Scotia (excluding Cape Breton) and to narrow portions of interior British Columbia for plant hardiness.

HEATING AND AIR CONDITIONING

To achieve indoor temperatures near a comfortable 21°C, heating is required in winter, while air conditioning often is needed in summer. The relative costs of heating or cooling buildings as a function of climate can be determined using indices called **heating degree-days** and **cooling degree-days**.

The heating degree-day index is calculated by accumulating the number of degrees that the average daily temperature falls below a

TABLE 17

Average heating degree-days (below 18°C) and cooling degree-days (above 18°C) for various cities in Canada (1951-80)

City	Average Heating degree-days (°C)	Average cooling degree-days (°C)
Whitehorse	6988	6
Vancouver	3031	36
Edmonton	5484	70
Regina	5877	137
Toronto City	3646	347
Montreal	4198	327
Halifax	3880	93
St. John's	4607	42

reference temperature, 18°C. Empirically, the index has been found to correlate well with the amount of fuel needed to keep the interior of a building at 21°C during cool weather. While wind speed, sunshine, and cloudiness each have a bearing on the actual net heat loss from the building, the effect of temperature is the most significant. For outdoor temperatures above 18°C, the cooling degree-day index can be used to estimate indoor cooling requirements.

Heating degree-days below 18°C average 3646 units at Toronto (city). This amount is considerably less than that observed for many other Canadian cities, as shown in Table 17. Assuming that the cost of fuel is the same across Canada, heat for a building in Regina could cost 65 per cent more than heat for the same building in Toronto, but 15 to 20 per cent less in Vancouver.

In the Toronto area, the lowest heating costs are incurred in the city core. Heating degree-days are some 5 per cent higher at Toronto Island Airport, 9 per cent higher at Toronto Downsview Airport, and 15 per cent higher at Pearson Inter-

TABLE 18

Average heating degree-days (below 18°C) for various sites in the Toronto area

Site	MONTH													PERIOD OF RECORD
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
Toronto (city)	701	617	536	314	150	31	3	7	67	220	393	607	3646	1951-80
Toronto Downsview A	758	678	572	342	166	42	7	14	83	250	425	655	3992	1956-80
Pearson Int'l A	767	680	588	355	188	52	12	20	102	272	441	667	4144	1951-80
Toronto Island A	710	647	554	356	200	54	9	12	74	244	401	646	3877	1957-80
Toronto Met Res Stn	766	683	590	352	181	49	11	20	98	267	439	669	4125	1965-80
Richmond Hill	787	703	599	362	179	49	10	19	99	277	452	690	4226	1959-80
Lakeview MOE	708	632	555	351	203	57	13	17	86	247	405	606	3880	1963-80

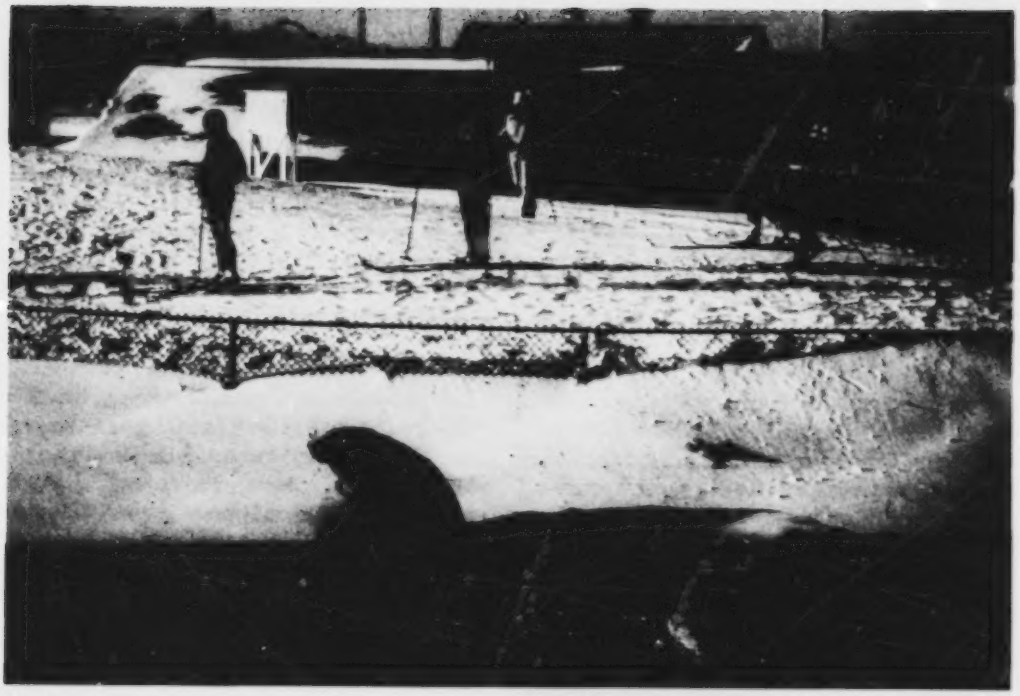
national Airport and Richmond Hill (see Table 18).

The heating degree-day statistics from Table 18 indicate that negligible heating is required during the summer. Heating quickly becomes indispensible from October to May, with demands peaking in January. January heating degree-days have varied from values as low as 545 units in 1880 to values as high as 933 units in 1857. More recently, the winter of 1976-77 sustained unusually cold weather. January, 1977, marked the first time since records began at Toronto (city) in 1840 that the temperature did not go above freezing in a calendar month; the monthly heating degree-days totalled 839 units (20 per cent above average), the highest since 1920.

The requirements for cooling are less than those for heating. Annual cooling degree-days above 18°C average 347 units. Locally, the accumulated cooling degree days reach their highest values in Toronto (city) and decrease nearly 30 per cent at Pearson International Airport and Richmond Hill. At Toronto Island Airport, Lake Ontario provides some natural "air conditioning comfort" and cooling degree days average about 38 per cent less than for the city core. July and August are the main air conditioning months.

The annual cooling degree-days for downtown Toronto are, on average, almost 10 times greater than those of Vancouver, 3 times those of Regina, 4 times those of Halifax, and slightly higher than those of Montréal. A cooling index designed to consider humidity as well as temperature would likely indicate an even greater need for summer air conditioning in Toronto.

(Mary Anne Augustyn)



RECREATION

Summer recreational activities, including picnicking, hiking, golfing, fishing, and boating, are possible for at least 7 to 8 months of the year in the Toronto area. Most of these activities can begin in April when the ground becomes dry and bays are open and last until November. Only activities such as outdoor swimming, water sports, and sunbathing await the warm weather of "high summer". The high summer season, described as the time when "shirt sleeve weather" prevails and mean daily temperatures exceed 18°C, extends from late May until late September, with its peak occurring in late July. Water temperatures along the shore of Lake Ontario warm to acceptable swimming temperatures during July and August. During midsummer, however, occasional humidex values of 30°C or more can curtail vigorous activities for some people.

Winter tourist and outdoor recreational activities require air temperatures that fall within a specific range, since low temperatures and high wind chills provide a handicap to outdoor activities, while thawing temperatures cause a spoiling of snow and ice surfaces and can give flooding. The winter activities pursued when snow or ice cover are present include skiing, snowmobiling, and skating. The snow cover in the city is quite unreliable until late December or early January, and often disappears a few times during mid-winter before melting for a final time in March. The peak winter recreation season occurs during January and February, when the probability that the snow cover will be suitable on a given day reaches 50 to 60 per cent, on average. Snow and its attendant recreation activities tend to be somewhat more reliable well north of the city, where melting does not occur as often and snow depths are considerably higher.

SECTION IV
CLIMATE CHANGE AND VARIABILITY

In the Toronto area, weather records indicate considerable climate variability. The longer records show that anomalies lasting several years or even decades are both common and inherent to the existing climate. The early 1800s, for example, were abnormally cold. Inference from old newspapers, legislative reports, and personal accounts in Ontario indicate a "year without a summer" in 1816. During June of that year, snow fell to measurable depths throughout much of eastern Ontario and the Province of Quebec on more than one occasion. One explanation given by climatologists for this summer, which affected many parts of the world, is that a tremendous volcanic eruption in Indonesia the previous year produced significant amounts of dust that later cooled temperatures around the globe.[1] The remainder of the 1800s were noted for a warming and then another cooling trend. The 20th century has seen variable temperatures during the early 1900s, a noticeable warming from 1940-60, and temperatures closer to the 100 year average during the 1970s and 1980s.

Drought and excessive moisture also have occurred periodically. These years of wetter and drier weather have not necessarily occurred in phase with the temperature variations. During 1877, for example, Toronto's annual precipitation only reached 652 mm, while the following year brought an annual precipitation total of 1233 mm. In general, recorded amounts of total precipitation have tended to decline about 10 to 20 per cent since the late 1800's. Since the late 1970's, however, amounts in the Toronto area have occasionally approached those of the previous century.

Generally speaking, the 1980's have been noted for many global climatic extremes of seemingly anomalous nature. In fact, many scientists now believe that the world climate has become increasingly variable. Unfortunately, it is extremely difficult, if not impossible, to verify whether climatic variability within the time span of a decade can be identified as the beginning of a climatic trend or a component of the existing climate.

Scientific opinion has tended to the view that climatic change in the form of global warming is around the corner or even in progress. Global mean surface temperatures clearly indicate unusual developments during the past decade, including the occurrence of the four warmest years during the past century. Over the next few decades, global temperatures are expected to rise due to human-induced increases of "greenhouse gases" (like carbon

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[1] Excess dust in the atmosphere reduces the sunlight that reaches (and warms) the earth's surface.

dioxide and the chlorofluorocarbons or CFCs) into the atmosphere. Computer models simulating the earth's climate currently estimate that average world temperatures could increase between 1.5° and 4.5°C before the middle of the next century.

In future, global society likely will have to respond to climate change. Some adjustments may even be required now or in the near future. Indeed, "many important economic and social decisions are being made today on long term projects... such as irrigation and hydro-power; drought relief; agricultural land use; structural designs; and coastal engineering projects - all based on the assumption that past climatic data are a reliable guide to the future" (World Meteorological Organization).

In the Toronto area, the implications of a warmer climate are varied. One scenario, described by Allsopp et al (1988) and based on experimental computer model output, projects that a warmer climate would bring about savings in the costs for heating that should exceed the added costs for increased summer cooling. On the other hand, lower water levels in the Great Lakes could possibly create hardships for marine transportation and waterfront facilities. A warmer climate and an extended growing season would require a change to plants and crops similar to those currently grown farther south. Warmer summers could also bring about an added demand for water, thereby increasing the demand for treatment services and surface water distribution systems. Summer recreational activities are expected to increase as a result of a longer summer season. On the other hand, a shorter and warmer winter would decrease winter activities, like skiing, in Toronto and surrounding localities.

(Mary Anne Augustyn)

SECTION V
TORONTO AND THE WORLD

Of Canada's large cities, Toronto is one of the most southerly in latitude and has some of the warmest summers. The temperature in Toronto varies more throughout the year than it does in coastal cities like Vancouver or Halifax, that experience a maritime influenced climate. These coastal cities receive cooler summers, warmer winters, and often receive significantly more total precipitation. Toronto enjoys a winter much milder than the Canadian Prairies. The city receives precipitation evenly distributed throughout the year, while Prairie localities receive most of their precipitation during the summer months. Of the major Canadian cities, Montreal probably has a climate most similar to Toronto's. While Montreal's summers are only slightly cooler, its winters are colder, more vigorous, and bring 75 per cent more snow.

Within southern Ontario, mean temperatures generally decrease from south to north. As a result, Toronto is cooler than Windsor or St. Catharines, in spite of its heat island effect, but warmer than localities to the north of its boundaries such as Barrie, or sites in

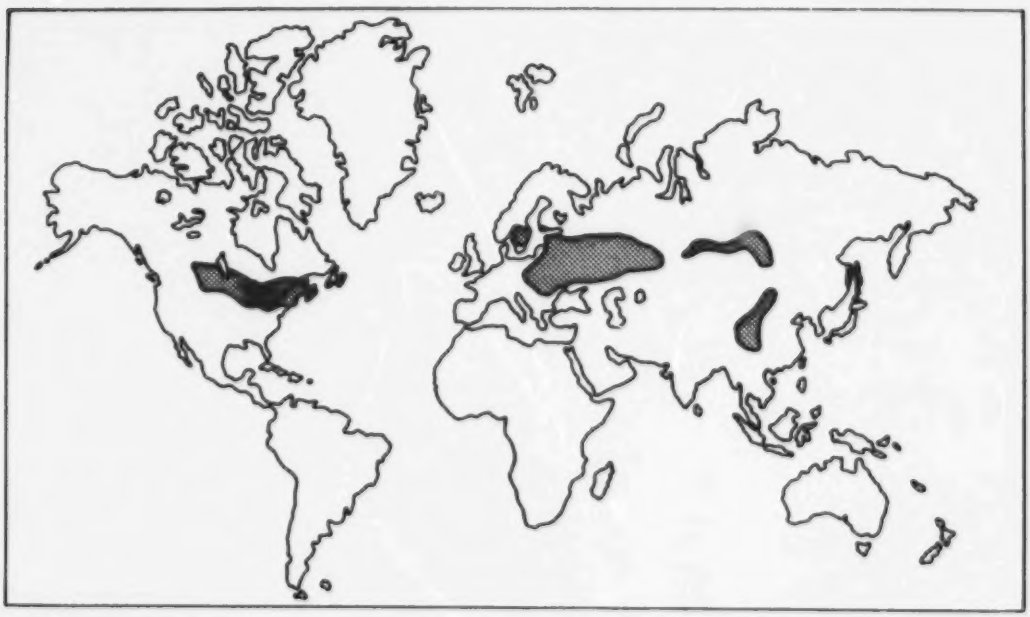


Figure 7. Areas of the World having a similar climate to that of Toronto (Eichenlaub, 1979)

TABLE 19

Toronto and the World

Site		Coordinates			Temperature (°C)		Precipitation (mm)			
		Lat.	Long.	Elev. (m)	Jan.	July	Seasons Winter	Spring	Summer	Fall
Canada										
Whitehorse	Yukon	61N	135W	702	-16/-25	20/ 8	50	40	100	70
Vancouver	British Columbia	49N	123W	39	5/ 0	22/13	500	240	130	360
Edmonton	Alberta	54N	114W	676	-11/-22	22/ 9	70	80	240	70
Regina	Saskatchewan	50N	105W	574	-13/-23	26/12	50	90	180	70
Winnipeg	Manitoba	50N	97W	239	-14/-24	26/13	60	130	230	110
Thunder Bay	Ontario	48N	89W	199	- 9/-21	23/17	111	169	235	197
Kapuskasing	Ontario	49N	82W	218	-13/-24	23/11	140	180	260	240
Sudbury	Ontario	47N	81W	347	- 9/-19	24/13	170	180	250	260
Windsor	Ontario	42N	83W	190	- 1/- 9	28/17	180	220	260	190
Trenton	Ontario	44N	77W	86	- 3/-12	26/15	220	200	200	230
Ottawa	Ontario	45N	76W	114	- 6/-15	26/15	200	200	250	230
Montreal	Quebec	45N	74W	57	- 5/-12	26/17	240	240	280	260
Fredericton	New Brunswick	46N	67W	40	- 4/-14	26/13	310	250	260	290
Halifax	Nova Scotia	45N	64W	25	0/- 7	23/14	370	300	280	340
Charlottetown	Prince Edward Is.	46N	63W	55	- 3/-11	23/14	340	260	250	310
St. John's	Newfoundland	48N	53W	140	0/- 7	21/11	460	330	240	380
United States										
Atlanta	Georgia	34N	84W	308	11/ 1	31/21	320	360	310	230
Chicago	Illinois	42N	88W	185	1/ -7	29/19	140	240	270	200
Denver	Colorado	40N	105W	1591	7/ -9	31/15	45	150	130	75
Houston	Texas	30N	95W	12	17/ 6	34/23	280	290	330	320
Kansas City	Missouri	39N	95W	238	4/ -5	33/22	100	270	290	200
Las Vegas	Nevada	36N	115W	659	12/ 0	40/24	35	20	25	20
Los Angeles	California	34N	118W	30	19/ 8	28/18	200	90	0	60
Miami	Florida	26N	80W	2	24/ 14	32/24	140	320	540	520
Nashville	Tennessee	36N	87W	180	9/- 1	33/21	360	320	250	220
New York	New York	41N	74W	40	4/- 3	29/20	240	280	290	260
Phoenix	Arizona	33N	112W	340	18/ 2	41/24	65	30	50	45
Salt Lake City	Utah	41N	112W	1286	3/- 8	34/16	95	120	65	75
San Franciso	California	38N	122W	2	13/ 6	22/12	290	110	5	65
South and Central America										
Acapulco	Mexico	17N	100W	3	29/ 21	32/24	20	35	790	550
Bogota	Colombia	5N	74W	2547	19/ 9	31/26	120	120	180	340
Buenos Aires	Argentina	35S	58W	27	29/ 17	14/ 6	250	270	180	250
Caracas	Venezuela	10N	67W	1041	24/ 13	26/16	80	125	320	310
Lima	Peru	12S	77W	120	28/ 19	19/14	5	5	20	15
Port-au-Prince	Haiti	19N	72W	37	31/ 20	35/23	125	480	320	430
Rio de Janeiro	Brazil	23S	43W	61	29/ 23	24/17	380	310	140	250
San Salvador	Salvador	14N	89W	682	32/ 16	32/19	25	250	920	590
Santiago	Chile	33S	71W	520	29/ 12	15/ 3	10	80	220	55

TABLE 19 (Cont'd)

Toronto and the World

Site		Coordinates			Temperature (°C)		Precipitation (mm)			
		Lat.	Long.	Elev. (m)	Jan.	July	Seasons Winter	Spring	Summer	Fall
Europe										
Athens	Greece	38N	24E	107	12/ 6	32/22	170	75	30	130
Berlin	Germany	52N	13E	57	2/- 3	23/13	130	130	190	130
Lisbon	Portugal	39N	9W	95	13/ 8	26/17	260	180	30	220
London	England	51N	0W	45	7/ 2	23/13	140	130	150	170
Madrid	Spain	40N	4W	667	8/ 1	31/17	110	120	50	130
Moscow	U.S.S.R.	56N	38E	154	- 6/-13	24/13	110	130	220	160
Oslo	Norway	60N	11E	94	- 1/- 7	23/13	130	120	230	200
Paris	France	49N	2E	50	6/ 0	24/13	120	130	160	160
Rome	Italy	42N	13E	115	12/ 4	31/18	260	150	45	290
Warsaw	Poland	52N	21E	90	- 1/- 6	24/13	95	120	220	130
Africa, Asia and Australia										
Bangkok	Thailand	14N	101E	16	32/ 19	32/24	35	220	560	650
Calcutta	India	23N	88E	6	27/ 13	32/26	45	220	950	390
Casablanca	Morocco	34N	8W	50	17/ 7	26/18	170	110	5	110
Shanghai	China	31N	121E	5	8/ 0	33/24	150	270	460	260
Dakar	Senegal	15N	17W	40	26/ 18	31/24	10	0	360	170
Hong Kong	Hong Kong	22N	114E	33	18/ 13	31/26	110	500	1140	410
Cairo	Egypt	30N	31E	116	18/ 8	36/21	15	10	0	0
Melbourne	Australia	38S	145E	35	26/ 14	13/ 6	150	170	150	180
Nairobi	Kenya	1S	37E	1820	25/ 12	21/11	190	490	85	190
Singapore	Singapore	1N	104E	10	30/ 23	31/24	680	550	540	640
Tokyo	Japan	36N	140E	6	8/- 2	28/21	180	390	460	540
TORONTO (CITY)	**ONTARIO**	**44N**	**79W**	**111**	**- 1/- 8**	**27/17**	**190**	**210**	**210**	**200**

"cottage country". The Toronto area receives slightly less precipitation (up to 20 per cent less) than most of the remainder of southern Ontario, perhaps reflecting the fact that the city does not lie in a snowbelt area and infrequently receives additional lake-induced precipitation. Toronto is less affected by summer severe weather than sites in the extreme south of the province.

While each part of the world may feel that its climate is unique, repetitions do occur. Various approaches are available to objectively group and then compare the climates of the earth. One scheme that classifies world climates (J.K. Litynski) would claim that, on a global scale, the climate of Toronto is moderate in temperature, moderate for precipitation totals, and intermediate in its continentality, which is a measure of the annual variation of temperature.

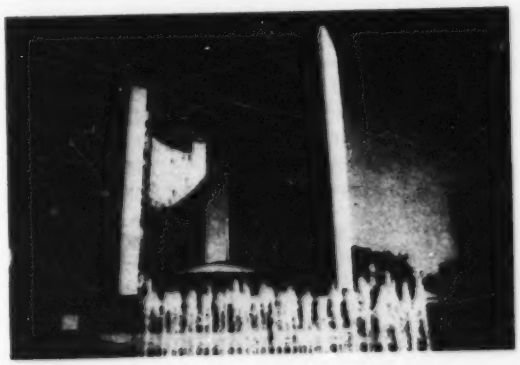
Within North America, the Toronto area experiences a climate similar to that found in a narrow latitudinal band from Wisconsin to western New Brunswick. Across the Atlantic Ocean, a large portion of central and eastern Europe claims a similar classification of climate

(see Figure 7.) In particular, the climate of some areas of Poland and Hungary comes closest to approximating that of Toronto. However, these countries do not experience the influences of arctic air masses as strongly as in North America, with the result that their winters are more temperate and little snow is received. Precipitation in central and eastern Europe occurs mostly during the summers.

Toronto's climate is a bit harsher than that of central and eastern Europe or of many other cities in North America. However, some experts working in the field of human effort claim that a climate with some element of vigour is an asset for optimum human energy and endeavour.

Overall, the climate of the Toronto area is sometimes beneficial, often beneign, and even occasionally hazardous. Whatever the description used, this invigorating climate has provided the area with its share of benefits. Whether these benefits will increase, remain the same, or become diminished in the future is a question that remains to be answered. If climate change takes place in the near future, as seems likely, Torontonians will have to adapt to these changes by mitigating negative effects and taking advantage of the benefits. The challenge ahead lies in planning for the uncertainties associated with these changes.

(Mary Anne Augustyn)



(Jim McCulloch)

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GLOSSARY

air mass: Vast body of air that has developed properties characteristic of the surface that it had previously overlain.

climate: The climate of a specified area is represented by the statistical collective of its weather conditions during a specified period of time (usually several decades).

climate change: A change over time producing a lasting shift in the mean temperature or precipitation or in the probability of extremes. When studying the significance of an anomalous event, such as a change in mean temperature of 2°C over several years, it is necessary to consider the anomaly in relation to the vast climatic changes that have occurred in the recent past. The climate trends accompanying the glacial ages of the past two million years are considered examples of climatic change.

continental climate: Climate characteristic of the interior of large continents. Its distinctive features are a large annual range of temperature and daily temperatures that can vary considerably from day-to-day.

cooling degree-days: An index that estimates the energy requirements for air-conditioning or refrigeration. One cooling degree-day is counted for each degree that the daily mean temperature is higher than a base temperature of 18°C.

dew point temperature: The temperature to which air must be cooled, at constant pressure and constant water vapour content, in order for saturation to occur.

frost: An occurrence identified by a minimum temperature of zero or less (during the growing season), as measured at a height of 1.3 metres.

frost-free period: Time in days between the last occurrence of frost in spring and the first occurrence in autumn.

heating degree-days: An index that estimates the energy requirements for heating a building. One heating degree-day is counted for each degree that the daily mean temperature is lower than a base temperature of 18°C.

humidex: An index used to indicate human discomfort felt as a result of heat and humidity. The humidex value represents the temperature of dry air that is equivalent in comfort to air of a specific temperature and moisture content.

Indian summer: Term applied in North America to a period of calm and abnormally warm weather following the first freeze of the season. In southern Ontario Indian summer normally occurs in October or early November.

lake breeze: Wind blowing by day from a large lake surface towards the land as a result of heating of the land surface.

relative humidity: Quantity of water vapour in a volume of air expressed as a percentage of the quantity the same air could hold if it reached saturation. The quantity of water vapour necessary to saturate a given volume of air increases with its temperature.

snow gauge: Apparatus that measures snowfall and its water equivalent. Water equivalent is determined either by melting the snow or by measuring the weight of the snow.

water vapour: Water in the (invisible) gaseous phase.

weather: The day-to-day state of the atmosphere experienced at any time, as defined by the various meteorological elements.

weather systems: Anticyclones (high pressure areas) and cyclones (low pressure areas) and weather phenomena associated with them. Weather systems normally migrate from west to east and are responsible for transporting large amounts of air globally.

wind chill: A measure of the combined chilling effect of wind and temperature in creating discomfort. Wind chill can be expressed as an actual cooling rate for water in units of watts per square metre (W/m^2) or as an **equivalent wind-chill temperature** in degree Celsius. The equivalent wind-chill temperature relates temperature and wind conditions to the equivalent temperature felt under relatively calm conditions.

APPENDIX 1

CLIMATIC NORMALS FOR TORONTO (CITY)

TORONTO (CITY) (NORMAL 1951-1980)
(Extremes Based on 1840-1987)

Temperature (°C)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Daily Maximum	- 1.3	- 0.5	4.1	11.7	18.2	23.7	26.7	25.6	21.3	14.7	7.8	1.4	12.8
Extreme Maximum	16.1	14.4	26.7	32.2	34.4	36.7	40.6**	38.9	37.8	30.7	23.9	19.9	
Year	1967	1976	1946	1842	1969**	1964	1936	1918	1953	1963	1950	1982	
Daily Minimum	- 7.9	- 7.2	- 2.6	3.4	8.9	14.3	17.2	16.6	12.7	7.2	2.0	- 4.6	5.0
Extreme Minimum	-32.8	-31.7	-26.7	-15.0	- 3.9	- 2.2	3.9	4.4	2.2	- 8.9	-20.6	-30.0	
Year	1859	1855**	1868	1923	1874**	1943**	1843	1855	1842	1844	1875	1933	
Degree-Days													
Heating < 18°C	701	617	536	314	150	31	3	7	67	220	393	607	3646
Cooling > 18°C	0	0	0	1	13	62	126	105	38	2	0	0	327
Growing > 5°C	1	1	14	100	266	422	526	501	362	189	52	6	2440
Number of Days with													
Maximum Above 0°	13	14	24	30	31	30	31	31	30	31	28	19	312
Maximum Above 18°	0	0	*	4	15	27	31	31	22	8	*	0	138
Maximum Above 30°	0	0	0	*	*	2	5	3	1	0	0	0	11
Minimum Below 0°	28	26	22	6	*	0	0	0	0	1	10	24	117
Minimum Below -15°	5	3	*	0	0	0	0	0	0	0	0	2	10

* less than one day
** more than one year

TORONTO (CITY) (NORMAL 1951-1980)
(Extremes Based on 1840-1987)

Precipitation

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Rainfall (mm)	25.9	23.8	43.9	65.4	65.7	63.9	74.0	73.1	66.2	60.4	60.9	40.7	663.9
Snowfall (cm)	36.4	28.5	24.7	7.6	0.1	0.0	0.0	0.0	TR	0.6	7.4	33.9	139.2
Total precipitation (mm)	60.9	51.8	69.7	72.9	65.8	63.9	74.0	73.1	66.2	61.0	68.4	72.8	800.5
Greatest Rainfall 24hr	63.5	43.4	43.7	59.7	68.6	63.5	98.6	93.5	87.9	86.9	79.5	49.5	
Year	1843	1855	1881	1850	1894	1957	1897	1905	1843	1954	1861	1870	
Greatest Snowfall 24hr	39.9	45.7	40.6	21.1	7.6	TR	0.0	0.0	TR	12.2	30.5	48.3	
Year	1966	1846	1870	1901	1875	1945			1956	1969	1950	1944	
Greatest Precipitation 24hr	63.5	52.6	43.7	59.7	68.6	63.5	98.6	93.5	87.9	86.9	79.5	49.5	
Year	1843	1965	1881	1850	1894	1957	1897	1905	1843	1954	1861	1870	
Greatest Precipitation for month	173.7	132.3	197.8	154.7	238.5	205.5	206.8	206.8	248.2	154.9	186.2	152.7	
Year	1932	1900	1870	1929	1894	1870	1841	1915	1843	1954	1985	1852	
Days with													
Precipitation (0.2 mm or more)	14	12	12	11	11	10	9	10	9	10	12	14	134
Rain	4	4	7	11	11	10	9	10	9	10	10	7	102
Snow	11	9	7	2	*	0	0	0	0	*	3	9	41
Freezing Precipitation	1	1	1	*	0	0	0	0	0	0	*	1	4
More than 1.0 cm snow	7	6	5	1	*	0	0	0	0	*	2	6	27
More than 10 cm snow	1	1	1	*	0	0	0	0	0	*	*	1	4
More than 10 mm of Precipitation	2	1	2	3	2	2	3	2	2	2	2	2	25

APPENDIX 2

CLIMATIC NORMALS FOR PEARSON INTERNATIONAL AIRPORT

PEARSON INTERNATIONAL AIRPORT (NORMAL 1951-1980)
(Extremes Based on 1937-1987)

Temperature (°C)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Daily Maximum	- 2.5	- 1.6	3.3	11.5	18.4	23.9	26.8	25.8	21.3	14.6	7.2	0.4	12.4
Extreme Maximum	16.7	14.9	25.5	30.3	34.4	36.7	36.2	38.3	36.7	30.6	25.0	20.0	
Year	1980	1984	1945/6	1985	1962	1952	1975	1948	1953	1951	1961**	1982	
Daily Minimum	-10.9	-10.5	- 5.2	0.8	6.1	11.5	14.2	13.6	9.6	3.9	- 0.6	- 7.4	2.1
Extreme Minimum	-31.3	-31.1	-28.9	-17.2	- 5.6	0.6	3.9	1.1	- 3.9	- 8.3	-18.3	-31.1	
Year	1981	1943	1950	1972	1966	SVRL	1968	1965	1965	1969	1949	1942	
Degree-Days													
Heating < 18°C	767	680	588	355	188	52	12	20	102	272	441	667	4144
Cooling > 18°C	0	0	0	1	9	44	91	74	26	1	0	0	246
Growing > 5°C	0	0	8	75	227	382	482	456	314	145	33	4	2127
Number of Days with													
Maximum Above 0°	11	12	22	30	31	30	31	31	30	31	28	17	304
Maximum Above 18°	0	0	*	4	16	27	31	31	22	8	1	0	140
Maximum Above 30°	0	0	0	0	1	3	6	4	1	*	0	0	15
Minimum Below 0°	30	27	27	14	3	0	0	0	1	7	18	28	155
Minimum Below -10°	17	15	6	*	0	0	0	0	0	0	1	11	50
Minimum Below -15°	9	8	2	0	0	0	0	0	0	0	0	4	23
Frequency of Occurrence (% of total hours)													
Temperature Above 0°	19.0	22.5	48.0	87.0	99.2	100.0	100.0	100.0	99.9	96.4	76.2	34.1	73.7
Temperature Above 5°	1.4	1.9	12.7	54.7	90.0	99.4	100.0	99.9	97.2	78.0	37.9	5.8	56.8
Temperature Above 18°	0.0	0.0	0.2	3.4	18.0	48.0	69.5	63.4	32.8	6.8	0.3	0.0	20.3
Temperature Above 20°	0.0	0.0	0.1	2.0	12.1	36.0	56.9	49.6	22.9	3.4	0.1	0.0	15.4
Temperature Above 30°	0.0	0.0	0.0	0.0	0.3	1.6	3.4	2.1	0.9	0.0	0.0	0.0	0.7
Temperature Below 0.1°	81.0	77.5	52.0	13.0	0.8	0.0	0.0	0.0	0.1	3.6	23.8	65.8	26.3
Temperature Below -10°	30.9	26.9	6.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5	15.2	6.6
Temperature Below -15°	11.0	10.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	2.2

PEARSON INTERNATIONAL AIRPORT (NORMAL 1951-1980)
(Extremes Based on 1937-1987)

Precipitation

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Rainfall (mm)	21.3	20.6	37.1	61.8	65.8	67.1	71.4	76.8	63.5	61.0	55.2	35.6	637.2
Snowfall (cm)	33.4	26.6	22.3	7.4	TR	0.0	0.0	0.0	0.0	0.9	8.0	32.5	131.2
Total precipitation (mm)	50.4	46.0	61.1	70.0	66.0	67.1	71.4	76.8	63.5	61.8	62.7	64.7	761.5
Greatest Rainfall 24hr	58.7	31.8	41.7	41.7	92.7	43.9	118.5	80.8	108.0	121.4	86.1	40.9	
Year	1946	1975	1942	1951	1944	1957	1980	1970	1940/48	1954	1962	1962	
Greatest Snowfall 24hr	36.8	39.9	32.3	26.7	2.3	0.0	0.0	0.0	TR	7.4	33.5	28.2	
Year	1966	1965	1964	1939	1976				1956	1962	1940	1949	
Greatest Precipitation 24hr	58.7	55.9	41.7	41.7	92.7	43.9	118.5	80.8	108.0	121.4	86.1	40.9	
Year	1946	1965	1942	1951	1944	1957	1980	1970	1948	1954	1962	1962	
Greatest Precipitation for month	98.3	107.2	121.2	111.9	208.5	150.9	182.3	163.6	212.3	263.9	161.8	110.0	
Year	1947	1965	1973	1980	1942	1967	1980	1968	1986	1954	1985	1942	
Days with													
Precipitation (0.2 mm or more)	14	12	13	11	11	9	9	10	9	11	13	15	137
Rain	4	4	7	10	11	9	9	10	9	10	10	6	99
Snow	12	10	8	2	*	0	0	0	0	*	4	11	47
Freezing Precipitation	3	2	2	*	0	0	0	0	0	0	*	3	10
More than 1.0 cm snow	7	6	5	1	*	0	0	0	0	*	2	6	27
More than 10 cm snow	1	*	*	*	0	0	0	0	0	0	*	1	2
More than 10 mm of Precipitation	1	1	2	2	2	3	2	2	2	2	2	2	23
Frequency of Occurrence (% of total hours)													
Precipitation	27.6	23.5	19.0	14.2	10.6	7.7	5.1	6.5	8.5	11.3	17.8	26.6	14.8
Rain	3.6	4.0	6.7	10.9	10.5	7.7	5.1	6.5	8.5	10.8	11.6	7.5	7.8
Snow	23.1	19.2	11.9	3.7	0.2	0.0	0.0	0.0	0.0	0.6	6.4	18.5	6.9
Freezing Precipitation	1.6	0.8	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.2	0.4

PEARSON INTERNATIONAL AIRPORT (NORMAL 1955-1980)

Wind

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Percentage Frequency													
N	11.2	12.7	12.2	12.0	11.5	11.3	11.2	11.0	11.3	9.9	7.9	10.0	11.0
NNE	3.3	3.4	3.5	3.2	2.5	2.5	2.3	2.6	3.2	2.6	2.4	3.5	2.9
NE	3.2	3.0	3.7	2.3	2.4	1.6	1.5	1.9	2.3	2.5	2.6	3.9	2.6
ENE	2.4	2.5	3.4	3.2	2.5	1.3	1.2	1.3	2.0	2.2	2.7	3.5	2.3
E	3.0	4.3	8.1	8.2	6.2	3.5	2.4	2.9	4.2	4.8	4.5	3.6	4.6
ESE	2.4	2.2	3.4	3.5	3.6	2.9	2.1	2.5	3.4	3.8	3.8	3.2	3.1
SE	2.0	1.9	3.2	4.7	5.7	5.8	4.9	4.7	5.2	5.2	4.3	2.9	4.2
SSE	1.7	2.0	2.8	4.3	6.9	7.6	6.4	6.4	5.3	4.8	3.5	2.2	4.5
S	5.0	5.6	4.1	4.5	6.6	8.0	7.9	6.7	6.9	6.5	6.2	5.7	6.1
SSW	6.2	5.2	3.7	3.1	3.5	4.7	4.8	4.4	4.9	5.0	5.3	5.4	4.7
SW	10.7	6.9	5.1	4.8	5.5	6.9	6.9	7.4	6.9	7.7	8.6	9.7	7.3
WSW	13.1	8.2	5.6	4.6	5.0	6.0	6.4	6.7	5.7	7.5	11.0	10.8	7.5
W	12.2	12.7	11.3	10.1	8.8	9.4	10.7	10.4	10.3	10.8	13.4	11.4	11.0
WNW	6.3	7.4	8.6	8.3	7.3	6.8	7.5	7.1	6.5	6.1	7.0	5.9	7.1
NW	6.0	8.4	7.7	7.9	7.1	7.3	7.8	8.3	6.4	6.5	5.6	5.8	7.1
NNW	7.9	10.1	9.7	11.1	9.9	8.7	9.1	9.4	9.3	8.1	6.4	8.0	9.0
Calm	3.4	3.5	3.9	4.2	5.0	5.7	6.9	6.3	6.2	6.0	4.8	4.5	5.0
Mean Wind Speed in Kilometres per Hour													
N	16.7	17.1	15.7	15.8	15.5	14.4	12.8	12.4	12.9	13.3	14.6	16.0	14.8
NNE	14.2	15.1	14.0	13.9	12.3	11.7	10.8	11.5	12.4	11.9	12.4	13.5	12.8
NE	15.2	14.5	14.0	13.6	11.1	9.8	10.3	11.3	9.9	11.2	12.6	14.7	12.4
ENE	18.6	18.1	17.8	17.2	14.8	12.9	12.9	10.9	11.9	14.2	14.7	17.4	15.1
E	20.1	20.1	21.4	21.2	17.0	14.9	13.1	13.7	14.0	15.6	16.5	19.2	17.2
ESE	17.9	16.5	17.5	16.2	14.4	13.1	12.9	12.8	13.3	14.6	15.8	17.8	15.2
SE	13.9	12.3	11.9	13.3	12.4	12.4	12.5	12.3	11.9	12.3	12.5	13.3	12.6
SSE	12.7	11.8	12.0	13.6	12.8	12.5	12.9	12.6	11.8	11.9	12.2	11.2	12.3
S	14.0	13.0	11.7	12.3	11.9	11.0	11.5	11.2	12.0	12.1	13.8	13.0	12.3
SSW	17.4	16.7	16.9	17.3	15.1	13.8	13.2	12.9	15.3	15.6	17.1	15.6	15.6
SW	19.9	17.1	20.5	20.0	17.7	15.7	14.6	14.6	16.1	16.7	19.8	19.0	17.6
WSW	23.2	20.6	20.2	20.5	17.8	16.1	14.5	14.4	15.3	16.9	21.5	21.1	18.5
W	21.2	20.8	20.8	20.3	17.8	15.7	14.5	13.4	15.1	16.9	20.3	20.6	18.1
WNW	23.0	21.1	22.2	22.0	20.1	16.8	15.9	15.1	16.3	18.2	20.7	20.8	19.4
NW	19.1	20.2	20.2	19.3	16.6	14.8	13.6	13.2	14.4	15.7	18.1	18.2	17.0
NNW	19.1	19.6	19.6	20.0	16.8	15.5	13.6	13.1	14.2	15.5	18.0	19.3	17.0

PEARSON INTERNATIONAL AIRPORT

Wind (Cont'd)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Mean Wind Speed													
All Directions (1951-1980)	18.4	17.6	17.6	17.3	14.9	13.4	12.5	12.3	13.0	14.1	16.6	17.0	15.4
Maximum Hourly Speed (1937-1982)	77 WSW	77 NNW	97 SW	81 W	71 WSW	63 NW	61 E	71 WNW	69 SW	61 W	80 SVL	70 NNW	97 SW
Maximum Gust Speed	115 E	97 SVL	124 SW	111 W	98 SW	102 NW	89 WSW	93 WSW	92 SW	96 WNW	97 SSW	95 W	124 SW
Frequency of Occurrence (% of all hours) (1953-1982)													
Calm wind	3.5	3.4	3.7	4.0	4.8	5.6	6.7	5.9	5.8	5.6	4.5	4.2	4.8
Wind 1 - 10 km/hr	20.9	24.0	24.6	24.9	31.1	35.5	37.6	39.9	37.8	33.6	27.2	24.6	30.2
Wind 11 - 20 km/hr	37.6	36.9	35.4	35.8	38.5	38.9	38.9	38.6	37.2	39.0	36.6	36.9	37.5
Wind 21 - 30 km/hr	25.1	23.5	23.0	22.8	18.7	15.9	13.8	13.4	15.0	15.8	20.8	23.2	19.2
Wind 31 - 40 km/hr	9.8	9.5	9.8	9.2	5.8	3.4	2.8	2.0	3.7	4.9	8.3	8.8	6.5
Wind 41 - 50 km/hr	2.4	2.1	2.7	2.5	0.9	0.5	0.3	0.2	0.4	0.9	1.8	2.0	1.4
Wind 51 - 60 km/hr	0.6	0.6	0.7	0.6	0.2	0.1	0.0	0.0	0.0	0.1	0.6	0.4	0.3
Wind 61 and more	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1

Other Elements

(Normal 1982-1982; Extremes 1953-1987)

Days with													
Thunder	0	*	1	2	3	5	6	5	3	1	1	*	27
Fog (visibility ≤ 1km)	2	3	3	3	3	2	2	3	3	4	3	4	35
Station Pressure (kPa)													
Highest	102.16	102.67	102.01	101.86	101.24	101.15	100.71	100.77	101.39	101.42	101.84	102.37	
Year	1968	1979	1967	1981	1976	1976	1981	1967	1965	1986	1984	1971	
Lowest	94.15	95.32	95.52	95.76	96.83	97.06	97.46	97.39	96.86	96.62	96.10	95.64	
Year	1978	1965	1973	1970	1969	1972	1963	1963	1967	1965	1972	1962	

PEARSON INTERNATIONAL AIRPORT (NORMAL 1953-1982)

Other Elements (Cont'd)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Humidity													
Dew Point (°C)	- 9.5	- 8.9	- 4.7	0.4	5.9	11.7	14.1	14.1	10.7	5.2	0.3	- 6.0	2.8
Vapour Pressure (kPa)	0.34	0.35	0.47	0.67	0.99	1.44	1.66	1.66	1.36	0.94	0.67	0.43	0.92
Frequency of Occurrence (% of all hours)													
Relative Humidity													
greater than 90%	16.33	16.21	18.49	16.04	14.77	14.83	14.67	20.73	24.76	25.79	26.63	24.03	19.45
greater than 70%	86.20	82.36	73.85	55.75	49.84	53.58	52.59	59.86	66.75	71.21	82.72	89.98	68.67
greater than 40%	99.95	99.95	99.20	92.61	91.12	94.23	93.58	96.94	97.97	98.43	99.90	99.96	96.97
less than 30%	0.01	0.0	0.25	2.06	2.41	0.96	1.03	0.16	0.16	0.27	0.02	0.00	0.61
Cloud Cover (%)													
Frequency of Occurrence													
Clear (0-10)	20.1	23.2	26.1	27.9	27.8	27.7	32.7	32.2	31.6	28.8	15.3	16.7	25.9
Scattered (11-50)	10.1	10.7	10.5	11.8	13.8	17.1	19.7	18.1	15.4	12.6	9.8	8.8	13.2
Broken (51-90)	24.2	23.8	23.5	25.8	29.9	32.7	32.4	30.5	29.4	29.7	29.4	23.9	28.0
Overcast (91-100)	45.6	42.3	39.9	34.5	28.5	22.5	15.2	19.2	23.6	28.9	45.5	50.6	33.0

APPENDIX 3

CLIMATIC NORMALS
IN THE TORONTO AREA

NORMAL VALUES**

STATION NAME	TEMPERATURE (°C)				DEGREE DAYS			FROST				ANNUAL PRECIPITATION					PERIOD of RECORD*
	January		July		ANNUAL TOTAL			DATE OF LAST SPRING FROST		DATE OF FIRST FALL FROST				NUMBER OF DAYS WITH			
	Max.	Min.	Max.	Min.	Heating	Cooling	Growing	Average	Latest*	Average	Earliest*	Rain (mm)	Snow (cm)	Rain	Snow	Prec.	
Metropolitan Toronto																	
Toronto (city)	- 1.3	- 7.9	26.7	17.2	3645.9	347.1	2440.4	Apr 20	Jun 10	Oct 29	Sep 20	663.9	139.2	102	41	134	1840-1980**
Toronto Agincourt	- 3.0	-10.9	26.3	15.3	4109.5	250.7	2162.0	May 8	May 27	Oct 9	Sep 10	675.5	146.2	98	35	132	1895-1968**
Toronto Beacon Road	- 2.2	- 9.4	27.0	15.6	3931.3	287.6	2262.8	May 3	May 24	Oct 13	Sep 21	686.0	145.0	98	45	135	1962-1975
Toronto Castlemere	- 2.5	- 9.7	26.9	15.9	3968.8	270.9	2295.7	May 1	May 8	Oct 8	Sep 21	659.8	162.9	98	43	136	1971-1980
Toronto Downsview A	- 2.6	-10.3	27.2	15.6	3991.5	312.6	2299.2	May 4	May 26	Oct 16	Sep 23	626.5	147.9	103	51	144	1956-1980
Toronto Ellesmere	- 2.5	-10.9	26.2	15.7	3992.3	275.2	2290.3	May 3	May 24	Oct 13	Sep 16	669.9	107.1	86	22	107	1959-1980
Toronto Etobicoke	- 1.4	- 8.7	27.6	16.1	3780.6	327.7	2359.6	May 4	May 19	Oct 12	Sep 23	647.6	105.1	89	23	112	1971-1980
Toronto Island A	- 1.7	- 8.1	24.7	15.8	3876.9	214.7	2135.0	Apr 21	May 10	Oct 30	Oct 3	644.1	119.4	99	38	130	1957-1980
Toronto Islington	- 1.7	- 9.9	26.8	15.2	3963.8	263.3	2213.4	May 6	May 26	Oct 10	Sep 17	670.8	120.6	98	38	131	1951-1975
Toronto Malvern								May 2	May 8	Oct 11	Sep 24						1974-1980
Toronto Met Res Stn	- 3.0	-10.4	26.5	14.8	4124.4	259.8	2169.5	May 13	Jun 11	Sep 29	Aug 30	619.2	120.0	97	41	134	1965-1980
Toronto Northcliffe	- 1.9	- 9.0	27.1	16.1	3772.3	320.8	2364.0	Apr 26	May 8	Oct 19	Oct 3	667.2	119.9	100	38	132	1968-1980
Pearson Int'l Airport	- 2.5	-10.9	26.8	14.2	4143.8	246.0	2126.8	May 8	May 28	Oct 5	Sep 15	637.2	131.2	99	47	137	1938-1980**
Toronto Scarborough	- 2.2	- 8.3	24.4	16.7	3938.9	236.3	2153.0	May 4	May 13	Oct 1	Oct 5	679.4	119.9	95	33	121	1967-1973
Toronto Wilson Hts	- 2.7	- 9.9	26.5	15.3	3999.4	282.6	2236.0	May 5	May 27	Oct 14	Sep 27	666.5	136.6	96	30	122	1953-1973
Nearby Stations																	
Brampton	- 2.9	-11.6	26.4	13.1	4320.6	197.7	2001.0	May 17	Jun 9	Sep 30	Sep 7	688.2	130.0	87	29	110	1950-1964
Burlington TS	- 1.4	- 9.3	27.7	15.8	3818.2	338.7	2357.7	May 5	May 25	Oct 11	Sep 17	700.8	121.6	91	24	112	1954-1980
Clarkson	- 1.2	- 8.2	27.6	16.7	3698.6	358.0	2404.1	Apr 25	May 24	Oct 24	Oct 3	681.0	124.0	76	18	97	1950-1967
King Creek	- 3.5	-12.6	26.5	12.8	4393.9	182.8	1967.8	May 24	Jun 11	Sep 25	Aug 30	618.9	142.3	99	43	139	1959-1978
Markham MOE	- 3.0	-11.2	26.2	14.0	4244.9	207.3	2040.3	May 18	Jun 11	Sep 25	Aug 30	670.1	120.7	89	28	113	1962-1980
Oak Ridges	- 3.7	-12.0	26.0	14.8	4321.9	244.1	2098.8	May 12	Jun 22	Oct 10	Sep 19	668.5	155.8	90	40	125	1918-1972**
Oakville	- 1.2	- 8.7	25.5	14.7	3914.7	222.9	2114.2	May 7	May 31	Oct 18	Sep 27	686.8	109.3	94	29	120	1958-1971
Richmond Hill	- 3.6	-11.2	26.2	14.8	4226.8	246.4	2138.4	May 7	May 30	Oct 5	Sep 17	646.7	157.7	105	55	151	1959-1980
Stouffville WPCP	- 3.4	-11.9	26.3	13.9	4269.6	240.2	2128.6	May 9	Jun 9	Sep 28	Sep 20	638.7	125.5	89	33	133	1971-1980

* Based on complete period of record

** Normal values bases on period of record except for Toronto (city) and Pearson Int'l Airport 1951-1980, Toronto Agincourt 1950 - 1968, and Oak Ridges 1950-1972

APPENDIX 4

NOTEWORTHY METEOROLOGICAL EVENTS OF THE PAST

APPENDIX 4

This Appendix describes some highlights of Toronto's past weather with emphasis on the recent past. References to these events, as well as noteworthy meteorological occurrences from other sites across Canada, can be found in the Canadian Weather Trivia Calendar (1985-1989).

January

On January 10, 1859, Toronto City's temperature fell to -33°C, a record low for any month of the year.

The temperature never went above zero Celsius in January, 1977, the only month without a thaw since records began in 1840.

A winter storm ravaged Toronto on January 26 and 27, 1978, giving winds to 90 km/h with gusts to 126 km/h and visibilities near zero in blowing snow. Air pressure plunged to an all-time low of 94.15 kiloPascals, while skyscraper windows popped. The storm closed many roads, resulted in over 400 injuries, and caused one woman to die from exposure. Costs and damages of the storm were estimated at 41 million dollars.

February

Monthly temperatures at Toronto City averaged -12.6°C in 1875 - the coldest month on record.

In 1899, flooding caused the Don River to overflow and the Queen Street Bridge and King Street car line to close for eight days. Huge ice floes threatened the bridge's superstructure.

The greatest depth of snow on the ground for any month, 43 cm was reported in 1982. (Snow depth data only begin in 1941).

In 1986, fog lingered for several days, stranding air passengers at Pearson International Airport.

In 1987, a winter storm in Toronto with winds to 100 km/h caused numerous multi-car pileups and forced flight cancellations. The next day, wind-chill equivalent temperatures dropped to -40°C and thousands of commuters were delayed when subway trains were disabled by the bitter cold.

March

On March 16, 1868, intense thunderstorms accompanied by hail and strong gusty winds brought considerable damage to Toronto's lakeshore.

March, 1870, brought 159 cm of snow to Toronto City - the greatest snowfall of any month. The first of 3 snowstorms struck the area on the 12th, giving a total snowfall of 38 cm. A second storm followed on the 15th, dumping 51 cm, and a third on the 27th gave 41 cm.

A winter storm on March 4, 1985, brought freezing rain followed by 25 to 35 cm of snow, resulting in the first snow emergency in years.

In 1987, Toronto City's temperature reached 18°C on the 7th - the highest ever reported so early in the year. Melting snow swelled creeks and rivers and some streets were covered with 60 cm of water.

April

On April 22, 1842, temperatures at Toronto City rose from 3°C to 32°C - a range of 29 degrees.

On April 13, 1858, strong winds over lake Ontario formed Toronto Island when the narrow isthmus connecting the peninsula to the mainland was breached.

April weather in 1985 included occasional snowfalls, a tree-toppling gale, thunderstorms, and a temperature of 30°C on the 22nd - the warmest temperature that year.

May

The coldest ever May temperature, -4°C, was recorded on the 7th, 1874. The warmest temperature for the month, 34°C, occurred on May 18, 1962, at the end of a three day heat wave.

In 1884, the latest measurable snowfall at Toronto occurred on the 16th (0.3 cm).

During a solar eclipse on May 26, 1954, Toronto's temperature, as recorded from thermometers exposed to the sun, fell 13 Celsius degrees.

On May 31, 1985, three tornadoes struck communities north of Metro Toronto, leaving 12 dead, hundreds of injuries, and thousands of destroyed or damaged buildings.

June

The latest spring frost occurred at Toronto City on June 10, 1842, when the minimum temperature dipped to -2°C.

On June 10, 1979, tornadoes caused locally heavy damage in Brampton, northwest of Metro Toronto.

On June 28, 1982, a torrential downpour of 86 mm in 6 hours near Georgetown, to the northwest of Metro Toronto, caused mudslides, flooded basements, and road and highway washouts.

July

The coldest ever July temperature, 4°C, occurred on the 12th, 1843.

July, 1921, was the warmest month in Toronto City's history with an average temperature on 25.5°C.

In 1936, an intense heat wave lasting 8 days from July 7-14 caused numerous human fatalities from heat prostration. Toronto's temperature reached 41°C on the 8th, 9th, and 10th, the highest ever for any month of the year.

In 1981, a week of severe weather across southern Ontario ended on the 19th with a very damaging storm north of Metro Toronto. Tennis-ball sized hail broke windows, damaged roofs, and stripped gardens, with costs estimated at millions of dollars.

On July 7, 1985, a tornado struck Mississauga, just west of Metro Toronto, resulting in 10 injuries and damages totalling 400 thousand dollars. The storm also forced a 90 minute delay of the Canadian Open at Glen Abbey Golf Course farther southwest.

During a 5-day heat wave from July 6-10, 1988, temperatures reached or exceeded 35°C. The maximum temperature reached 38°C on the 7th, the highest in 35 years.

August

On August 23, 1974, a heavy downpour of 45 mm in 30 minutes during the evening rush hour flooded many parts of Metro Toronto.

In 1986, severe thunderstorms struck eastern Toronto during the afternoons of the 27th and 28th, resulting in flooding and 2 millions dollars damage. Rainfalls of 149 mm in four hours were recorded.

Intense lightning from a sudden thunderstorm on August 13, 1976, disabled the weather radar at Pearson International Airport and struck 6 Air Canada maintenance workers.

A tornado struck the northwestern part of Metropolitan Toronto on August 14, 1984, causing extensive damage, estimated at 20 million dollars, to several buildings.

September

Toronto's longest heat wave (10 days) ended on September 4, 1953. The highest humidex reading, 48°C, was reached at Pearson International Airport on the 1st, when the temperature reached 36°C with a dew point temperature of 25°C.

In 1980, a line of severe thunderstorms crossed the city on the 2nd, giving wind gusts up to 100 km/h. The severe thunderstorms caused the deaths of 2 workmen when a building under construction was blown down.

September, 1986, was the rainiest at Toronto City since 1843 and the third wettest month ever. A rain-storm combined with strong winds on the 29th left power blackouts and flooded streets and basements. Rains caused the Don River to rise close to overflowing.

October

On October, 1844, southwest storm winds drove waters from Lake Ontario into the streets of Toronto, resulting in many drownings.

On October 1, 1920, the earliest measurable amount of snow (0.8 cm) fell on the city.

In 1954, Hurricane Hazel hit Toronto on the 15th and 16th, giving extensive

wind and flood damage costing 80 lives and 25 million dollars. Over a 72-hour period, the storm brought a deluge of 276 mm of rain to Brampton, northwest of Metro Toronto.

On October 21, 1969, 12.2 cm of wet snow fell, the heaviest ever for the month. The trees were still in full foliage, and the weight of the snow broke many branches and limbs.

November

A storm on November 21, 1906, with winds to 100 km/h sank a steam barge, The Resolute, off Toronto Island, resulting in 6 deaths.

In 1950, the greatest one-day November snowfall of 31 cm fell on the 24th, followed the next day by temperatures as high as 8°C. The Grey Cup football game was played on the 25th in spite of the soggy playing field.

The Grey Cup football game was played on November 27, 1965, during gale force winds. Wind was the deciding factor in determining the winner, with Hamilton beating Winnipeg 22 to 16.

The wettest November on record brought 172 mm of rain in 1985.

An early winter storm brought 14 cm of wet snow to Toronto City on November 20, 1986. The snow began during the early morning rush hour and continued all day, snarling traffic and extending the afternoon rush hour well into the evening.

December

Toronto's greatest Christmas snowstorm in 1872 gave 58 cm in 42 hours along with strong winds, temperatures of -16°C or lower, and very high wind chills.

A damaging freezing rain storm on December 27, 1959, brought 30 mm of glaze ice over 32 hours to sites north of Metro Toronto.

Dense fog and smog covered the city on December 1, 1962, causing the Grey Cup football game to be played over the course of 2 days. The incident was later renamed the "Fog Bowl".

Temperatures on Christmas Day, 1982, reached 17°C - the warmest Christmas in Toronto City's history.

On December 9, 1982, 11 mm of rain fell on the city, only to be followed by a "fast freeze" during the evening rush hour when temperatures suddenly dropped to -4°C. Treacherous conditions contributed to hundreds of accidents, many injuries, and two deaths.

FURTHER CLIMATIC INFORMATION

Further climatic information or advice can be obtained from the Canadian Climate Centre, Downsview, Ontario, or any of the various Atmospheric Environment Service regional offices.

Canadian Climate Centre

Assistant Deputy Minister
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario M3H 5T4
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Regional Offices

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Director, Western Region
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1496 Bedford Highway
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